CENTRE OF ADVANCED FACULTY TRAINING IN PLANT PATHOLOGY

(Indian Council of Agricultural Research, New Delhi)

Proceedings of the 25th Training

on

"Quality Management and Plant Protection Practices for Enhanced Competitiveness in Agricultural Export"

November 12 to December 02, 2011

Dr. J. Kumar, Director, CAFT

Dr. R.P. Singh, Course Coordinator

G.B. Pant University of Agriculture and Technology

Pantnagar- 263 145 (Uttarakhand)

PREFACE

India is the second largest producer of the agricultural produce particularly fruit and vegetables. About 30-40% produces is lost due to improper post harvest handling. In the International Agricultural trade share of our country is very less. In the recent past some export consignments have also been rejected due to non compliance of the Sanitary and Phytosanitary measures. Pesticides residue beyond tolerance level is also commonly reported in various food products. The producers and exporters are not aware of the codex alimentarious norms for various commodities. Some times bilateral trade negotiations require different requirements other then the codex norms. These situations necessitate high level of awareness among various stake holders. Further, improper plant disease management practices and inadequate post harvest handling leads to destruction of almost 40% produce.

In view of above, the 21 day training under Center of Advanced Faculty Training in Plant Pathology was designed to give an updated information/knowledge on "Quality Management and Plant Protection Practices for enhanced competitiveness in agricultural export" to the participants, so that they can deal with the opportunity and applicability of emerging technologies for enhancing the agricultural export. Excellent response was received from all over India for participation in this training. Fourteen participants representing seven states, who actively participated in the programme, were exposed to the recent advances made towards Climate change, precision agriculture and innovative disease control strategies through series of lectures, practical and field visits.

We are grateful to the ICAR for sponsoring this 25th advanced training programme in series, and 4th under the banner of the newly created Centre of Advanced Faculty Training in Plant Pathology at Pantnagar. We are highly grateful to Prof. B.S. Bisht, Vice-Chancellor for his constant support, guidance and encouragement in making the training a great success. We like to put on record the help and guidance received from Dean, College of Agriculture and Director, Experiment Station in the successful conduct of training programme. We sincerely acknowledge the services of our guest speakers Dr. Y.L .Nene, Hyderabad; Dr .Henerik G. Schlosser, Germany; Dr. D.V. Singh, New Delhi; Dr. Rakesh Pandey, CIMAP, Lucknow; Dr. Y.P. Singh, FRI, Dehradun; Drs. D.B. Parakh & Kavita Gupta, NBPGR, New Delhi; Dr. J.P. Singh, DPPQS, Faridabad; Mr. Ashok Agarwal, KLA, Rudrapur and Dr. R.K. Thakur, YPSPU, Solan. We would like to place on record the help and logistic support received from Dr. P.S.Bisht, Dean, Hill Campus, Ranichauri and his team of scientists for delivering lectures during exposure visit of participants. Several scientists from various departments such as Agronomy, Entomology, Agriculture Communication, Chemistry Biological Science, Microbiology, Molecular Biology & Genetic Engineering, Vet. Anatomy, Post Harvest Engineering and the University library in addition to the Plant Pathology rendered all possible help and delivered scientific lectures and designed practical exposure to the participants. We acknowledge their contributions with utmost gratitude and sincerity. We sincerely thank for very useful suggestions and guidance received from Dr. D.V. Singh, ex-Head, Deptt. Mycology & Plant Pathology, IARI, New Delhi for improvements the conduct of training.

Dr. R.P. Singh
Course Coordinator

Dr. J. Kumar
Director, CAFT

Pantnagar
December 02, 2011

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WELCOME ADDRESS

by

Dr. R.P. Singh

Course Coordinator

Senior Research Officer, Plant Pathology, College of Agriculture

G.B. Pant University of Agriculture & Technology, Pantnagar- 263 145

on

November 12, 2011

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Good morning and welcome to the Inaugural Session of the 25th Advanced Faculty Training on "Quality Management and Plant Protection Practices for enhanced competitiveness in agricultural export" organized by the Centre for Advanced Faculty Training in Plant Pathology .

Hon'ble Chief guest, Dr. B. S. Bisht, the Vice-Chancellor; Dr J. Kumar, Dean Agriculture, Dr. J.P. Pandey, Director Experiment Station, Dr. S.C. Saxena, Honorary Professor, Deans and Directors, Head of Departments, Senior faculty members, Colleagues, Staff members, the trainees from different Universities, Students, Press & Media, Ladies & Gentle men.

At the outset, on behalf of faculty of Plant Pathology and on my own behalf it is a pleasure in welcoming honorable Vice-Chancellor, Dr. B.S. Bisht, who is a big support and source of inspiration for the pursuance of research and academics in this Great University. He has a long distinguished professional career in various capacities in the country. He was responsible for designing, implementing and monitoring human resource development programmes of ICAR. You have consented to grace this occasion despite your very hectic schedule of work, we are all very grateful to you, Sir.

I welcome Dr J. Kumar, Dean Agriculture, Registrar, and Director Centre for Advanced Faculty Training in Plant Pathology. He is an alumnus of this University and as a Head of the Department maintained the rich heritage of the Department of Plant Pathology as well as the College of Agriculture.

It is my pleasure to welcome Dr. J. P. Pandey, the Director of Research who has been very successfully coordinating and leading a very diverse research programs in the university.

I would also like to welcome Dr. S.C. Saxena, the senior most person in the College and a honorary professor in the Department of Plant Pathology. Dr. Saxena is the First Generation Staff in the Department and a source of inspiration to the younger generations of the Department.

I welcome all the Deans and Directors who are present here in the hall. They have spared their valuable time to grace this occasion.

The Heads and faculty members of various departments have also responded to our request and are present in the hall. I welcome all of you to the function.

I would like to welcome the participants of the training from different universities, who have traveled a long distance to reach Pantnagar. We may not be able to provide you the comfort and attractions of big cities but we earnestly hope, we will be able to make up for our logistic inadequacies with our patent feeling of gratitude and warmth of our welcome and compensating the short comings of comfort and facilities of big cities by fresh air courtesy and excellent academic and scientific environment. We welcome you all and assure you a comfortable stay within our means.

In the last, but not the least, I welcome all our students and staff, press and media and others who are present in the hall and made the arrangements for this inaugural session.

Once again I welcome you all in this function.

Thanks a lot.

INAUGURAL ADDRESS

by

Prof. B.S. Bisht

Vice-Chancellor

G.B. Pant University of Agriculture & Technology, Pantnagar- 263 145

on

November 12, 2011

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I consider it a great privilege and honour to be called upon to Inaugurate the Training Course on "Quality Management and Plant Protection Practices for enhanced competitiveness in agricultural export" being organized by the Centre of Advanced Faculty Training (CAFT) in Plant Pathology. I am delighted to know that as many as 16 scientists from the all over India are participating in the training course. I extend my warm welcome to you all.

I am sure you know that Pantnagar University has a distinguished record of producing outstanding Plant Pathologists. The accomplishments of this Department have all become self-evident as the faculty members and their students have won more then 36 national/international awards from different recognized bodies like FAO, ICAR, Indian Phytopathological Society, Society of Mycology and Plant Pathology, and many others. On this particular occasion, I would like to make a mention of two giant plant pathologists, Dr. Y.L. Nene and Dr. R.S. Singh, who gave inspiring leadership to the Department of Plant Pathology during early 1960s soon after the establishment for the University on November 17, 1960. The discovery of *Khaira* diseases of rice due to zinc deficiency and its control turned this Tarai into rice bowl of the country. Thus the goal of establishment of first Agriculture University in India at Pantnagar was full filled. It was this single most important and simple factor in 1967 that earned a name for the university and the department by way of wining the FAO award by Dr. Nene. Dr. R.S. Singh worked out basic mechanisms for obtaining the disease control of soil-borne plant diseases through soil organic amendments which is now becoming a reality and way of organic farming. His books are considered to be the milestones for being handy text books both for under graduate and post graduate studies in Plant Pathology. This department has to its credits considerable number of research publications and several books have been published by most reputed national and international publishers.

India is one of the fastest growing economies of the world and is currently the focus of a great deal of international attention. It is the seventh largest country in the world in terms of its geographical size. Today it has a population of nearly 1.1 billion which makes it the second most populous nation in the world. With current population growth by 2025 India may even have caught up with China according to the UN.

Agriculture, a core sector of the Indian economy, accounts for 16 per cent of the country's GDP, 11 per cent of total export earnings, two thirds of country's workforce and livelihood for 70 per cent of the total population. The past accomplishments of this sector are a great strength to face the current problems and future challenges in the areas of greater efficiency (competitiveness), sustainability, poverty alleviation and continued food self-sufficiency. With trade liberalisation, agricultural exports have also become an important national goal. The new economic regime, initiated since early nineties, has led to resetting of the goals of Indian agriculture towards global competitiveness and export orientation without compromising the basic premise of self-reliance. The emergence of the concept of sustainability of agricultural production has made the task more difficult for all those who are associated with agricultural production systems in the country. The present goals of Indian agriculture warrant reformation of strategies and action plans. Agricultural exports increased from about 600 million US dollars in 1960-61 to 3520 million US dollars in 1990-91. During post economic reforms period, the value of agricultural exports has nearly doubled. The share of agri-exports in total exports, however, has remained more or less stable around 20 per cent, though the share of exports in agricultural GDP has been rising. Commodities such as marine products, oil meals, rice, coffee, tea, spices, cashew, tobacco, castor oil, groundnut, sesame, fresh fruits, vegetables, pulses etc., are important export earners and are being exported to more than 110 countries. The encouraging results of goal-oriented Green Revolution, White Revolution, Yellow Revolution etc. enthuse the agricultural fraternity of the country to set a new goal for 'Agri-Export Revolution' which is not only the need of the hour but also a compulsion to strengthen and revitalise the economy of the country. While India holds an important position in the export market for a set of traditional agricultural commodities, new areas and new commodities are likely to emerge.

Despite agriculture sector being not-taxed, prices of several agricultural commodities are below international prices, thus conferring trade advantages. Despite impressive strides that the country has made in agricultural production, India has not yet become a major player in the international arena as far as exports are concerned. The broad export strategy for Indian agriculture would, therefore, be to strengthen and widen the export market for established 'commercial commodities' like tea, coffee, spices, cotton, jute, sugar, oil meals etc., and also to create and capture new export market for 'dynamic commodities' like meat, dairy products, poultry, fishery products, vegetables, fruits, floriculture etc., whose demand in the international market is buoyant. India has a comparative advantage in many of these commodities due to availability of varied agro-climatic conditions, diversified commodity mix and low wage rates leading to lower cost of production etc. The major plank of our foreign trade strategy must be on finding a niche for exports of the above mentioned non-conventional and dynamic commodities. This has to be achieved in the context of stricter

control processes under Sanitary and Phytosanitary (SPS) Agreement and other non-tariff barriers.

India is one of the leading members of the G-20. It is also part of the South Asia Free Trade Agreement (SAFTA) covering seven nations (India, Bhutan, Nepal, Sri Lanka, Pakistan, Bangladesh and the Maldives) which came into effect in January 2006 with the aim of reducing tariffs for regional trade. And it is currently negotiating Free Trade Agreements with the EU and ASEAN. The European Union(EU) ranks as India's largest trading partner accounting for about 21% of total Indian trade in 2005, ahead of the United States and China. ASEAN is in 2nd place with 14%, although its share has fallen. Meanwhile trade with neighbouring Bangladesh and China is growing fast. The US market share has remained steady at 10% and also that of Saudi Arabia.

As regards the composition of agricultural exports, commodities represent around one third, intermediate products over one quarter and final products account for the remaining 40% of total agricultural exports. The single biggest export is milled rice, accounting for 16 % of the value of exports. Two other commodities, cotton and wheat, are also within the top 10 exports. Soybean meal, an intermediate product, is the second most important export with 9% of sales. However 6 out of the top 10 are final products, including cashew nuts, beef, coffee and tea which together represent around 14% of the value of exports.

India has managed to create a niche for itself in the global food market and is currently amongst the largest producers for some food products in world. These include production of grains like wheat and paddy, dairy, fruits and vegetables, marine products etc. A large domestic demand ensured that there was a ready market and thus an incentive for the producers to employ efficient means of production resulting in a larger quantity and better quality of output. As a result the processing industry has a growth rate of around 15 percent per annum. Agricultural growth though has been much less. Yet there remains a large untapped potential of growth which if exploited can help us emerge as the largest producer of major food items. Even though the food producing and processing sector has shown some growth during the past few years, there exists a plethora of problems that need to be addressed before it embarks on a high growth path. On the domestic front, better technology in all spheres of production and processing can result in greater efficiency. Better transportation and storage facilities are also required to mitigate the losses arising from spoilage and wastage of food. Some estimates suggest that currently around 20 percent of all foods produced in India are wasted. Further, easy credit availability is necessary, absence of which creates a bottleneck in addressing other issues.

On the international scene, focus has been shifted only that country would be better off if it exports processed food items, instead of primary output. India is the second largest producer of fruits and vegetables in the world, but only about 2 percent of it is processed. Similarly, even though we are the largest

producer of milk, only about 15 percent of it is processed by the organized sector. On an average, value addition to the raw produce in India is only 7 percent. This is much less as compared to 23 percent in China, 45 percent in Philippines, and 88 percent in United Kingdom.

The big challenge before the country is to encourage the exports of processed food products and the compliance of SPS Agreement. In the recent past awareness regarding importance of health measures and fear of health hazard has shown a definite upward trend. As a result an elaborate system of inspection and certification has evolved over the years. This system becomes more rigorous if the goods in question are to be sent to foreign markets. Yet imposition of more stringent SPS standards by the developed world would definitely have some repercussions on the trade of developing countries, including India. Some promising export-commodities for India like coffee, pulses, spices etc. may have to comply with certain stricter rules and regulations.

This is evident from the fact that rejections of Indian shipment by have increased several times. In 2003 grape consignment of 40,000 tonnes was rejected by EU because of chemical residues again in 2007 EU rejected 20 shipments. In 2007 US Food and Drug authority rejected 1700 food consignment of worth 1.2billion$. In the year 2009 6 shipments of basmati rice were rejected by US. These increased detentions and bans on Indian products by developed countries indicate that there is a need to upgrade system of compliance with the specified sanitary and phytosanitary norms. Though most of the exporting firms in India are following Codex standards, yet they have to face losses due to detained or rejected shipments. One major cause of this is the lack of availability of correct and timely information.

The Centre of Advanced Faculty Training in Plant Pathology at Pantnagar recognized the need for attention to role of Quality Management and Plant Protection Practices for enhanced competitiveness in agricultural export proves the importance of the subject for which the participants have come to study and participate in the discussions. No doubt the course is very timely and will deal with a field of study which has largely been neglected in many developing countries particularly in India.

The prime duty of the scientists participating in this course will effectively utilize the knowledge earned not only in doing research and teaching but also to find out ways and means of transferring the technology to the end user who is the sole judge of our efforts.

I declare the training course “Quality Management and Plant Protection Practices for enhanced competitiveness in agricultural export” open and I wish the training course, discussions and deliberations a grand success.

“Jai Hind”

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DEPARTMENT OF PLANT PATHOLOGY

Establishment of University	–	1960
Department created and Accredited	–	1961
M. Sc. (Ag) Programme	–	1963
Ph. D. Programme	–	1965
Ist course	–	Introductory Plant Pathology
Ist Instructor	–	Dr. Y. L. Nene
Ist HOD	–	Dr. Y. L. Nene

Courses:

06 UG courses

37 PG courses

Staff position:

08 Professor

02 Honorary Professor

01 Emeritus Scientist

05 Associate Professor

02 Assistant Professor

13 Technical staff

10 Supporting staff

The G.B. Pant University of Agriculture & Technology (earlier known as U.P. Agriculture University) was established in 1960. Department of Plant pathology was created and accredited by ICAR in 1961. The postgraduate degree programme leading to M.Sc. (Ag.) Plant Pathology and Ph.D. Plant Pathology were started in 1963 and 1965, respectively.

Faculty of Plant Pathology is highly qualified and includes 08 professors, 02 Honorary Professor, 01 Emeritus Scientist, 05 Associate Professors and 02 Assistant Professor with 13 technical staff and 10 supporting staffs.

Sl. No.	Name of Faculty members	Designation	Area of specialization
1	Dr. Serge Savary	Honorary Professor	Epidemiology
2	Dr. S.C. Saxena	Honorary Professor	Maize Pathology
3	Dr. J. Kumar	Professor & Head	Plant disease management on small farm, IPM, Biological control, Molecular characterization of Plant Pathogens
4	Dr. H.S. Tripathi	Professor	Pulse diseases & virology
5	Dr. R.P. Awasthi	Professor	Oilseed crop disease
6	Dr. K.S. Dubey	Professor	Soybean diseases

7	Dr. (Mrs.) K. Vishunavat	Professor	Seed Pathology
8	Dr. V.S. Pundhir	Professor	Epidemiology of crop disease
9	Dr. Pradeep Kumar	Professor	Maize Pathology
10	Dr. R. K. Sahu	Professor	Sugarcane diseases
11	Dr. Vishwanath	Assoc. Professor	Soybean Pathology
12	Dr. R.P. Singh	Sr. Research Officer	Vegetable & maize pathology
13	Dr. Yogendra Singh	Sr. Research Officer	Sorghum diseases
14	Dr. K.P.S. Kushwaha	Sr. Research Officer	Mushroom & pulse diseases
15	Dr. A.K. Tewari	Sr. Research Officer	Oilseed crops diseases
17	Dr. (Mrs.) Deepshikha	Jr. Research Officer	Wheat diseases
18	Dr. (Mrs.) N.W. Zaidi (EOL)	SMS	Bio-control

TEACHING

The department of plant pathology has made immense contribution in the area of teaching, research and extension. A well-knit UG and PG programme with updated and modern syllabi is already in operation in the department. The department offers 6 courses for undergraduate students. There are 37 postgraduate courses leading to M.Sc. (Ag.) and Ph.D. degrees in Plant Pathology. Since the inception of the department 325 M.Sc. (Ag.) and 185 Ph.D. students have been awarded degrees.

Under graduate courses:

Sl. No.	Course N0.	Course name	Credit
1.	APP-312	Introductory Plant Pathology	3(2-0-3)
2.	APP-314	Crop Diseases & their Management	2(1-0-3)
3.	APP-330	Diseases of Fruit and Vegetable Crops	2(1-0-3)
4	APP/APE-322	Integrated Pest & Disease Management	2(1-0-3)
5.	APP-381	Mushroom Cultivation	1(0-0-1x2)
6.	APP-382	Biological Control of Plant Pathogens	2(0-0-2x2)

Post graduate courses:

Sl. No.	Course N0.	Course name	Credit
1.	APP-401	Introductory Plant Pathology	3(2-0-1)
2.	APP-410	Diseases of Field Crops	3(2-0-1)
3.	APP-430	Diseases of Horticultural Crops	3(2-0-1)
4	APP-507	Disease of Field and Medicinal Plants	3(2-0-1)
5.	APP-508	Disease of Fruits, and Ornamental Crops	3(2-0-1)
6.	APP-509	Disease of Vegetable and Spice Crops	3(2-0-1)
7.	APP/ENT- 514	Insects Vector of Plant Viruses and other Pathogens	2(1-0-1)
8.	APP-515	Biological Control of Plant Diseases	3(2-0-1)
9.	APP-516	Integrated Disease Management	3(2-0-1)
10.	APP-517	Mushroom Production Technology	3(2-0-1)
11.	APP-519	Post Harvest Diseases	3(2-0-1)

12.	APP/ENT-520	Plant Quarantine	2(2-0-0)
13.	BBB-599	Mycology	3(2-0-1)
14.	APP-600	Master's Seminar	1(0-0-1)
15.	APP-601	Special Problem	1
16.	APP-602	Plant Virology	3(2-0-1)
17.	APP-603	Plant Bacteriology	3(2-0-1)
18.	APP-604	Principles of Plant Pathology	3(3-0-0)
19.	APP-606	Principles of Plant Disease Management	3(2-0-1)
20.	APP-607	Plant Biosecurity and Biosafety	2(2-0-0)
21.	APP-611	Chemicals in Plant Disease Management	3(2-0-1)
22.	BBB-615	Advanced Mycology	3(2-0-1)
23.	APP-616	Advanced Plant Virology	3(2-0-1)
24.	APP-617	Advanced Bacteriology	3(2-0-1)
25.	APP-618	Principles and Procedures of Certification	1(1-0-0)
26.	APP-622	Techniques in Phytonematology	1(0-0-1)
27.	APP-624	Cultural & Chemical Control of Plant Parasitic Nematodes	2(1-0-1)
28.	APP-630	Phytonematology	2(1-0-1)
29.	APP-690	Master's Thesis Research	20
30.	APP-704	Molecular Basis of Host Pathogen Interaction	3(2-0-1)
31.	APP-710	Seed Health Technology	3(2-0-1)
32.	APP-712	Ecology of Soilborne Plant Pathogens	3(2-0-1)
33.	APP-713	Disease Resistance in Plants	2(2-0-0)
34.	APP-718	Epidemiology and Forecasting of Plant Diseases	3(2-0-1)
35.	APP-788	Doctoral Seminar I	1(0-0-1)
36.	APP-789	Doctoral Seminar II	1(0-0-1)
37.	APP-790	Ph.D. Thesis Research	45

Books Published

The department has unique distinction of producing 33 books published by not only Indian but also reputed international publishers like Elsevier Science (UK), Gordon and Beach (UK), Prentice Hall (USA), CRC Press (USA), Science Publisher (USA), Lewis Publishers (USA) etc. It has also produced 13 technical bulletins. A number of text books in Hindi for U.G. students have been published. The faculty members have written/prepared several laboratory manuals, reference books, working sheets on diseases, bulletins, extension pamphlets, etc. for the benefit of U.G. and P.G. students of plant pathology as well as for the farmers.

(A) Hindi – (15) (B) English– (41)

- ***Plant Disease*** 8th Edition by R.S. Singh
- ***An Introduction to Principles of Plant Pathology*** 4th Edition by R.S. Singh
- ***Plant Pathogens: The Fungi*** by R.S. Singh
- ***Plant Pathogens: The Viruses & Viroids*** by R.S. Singh
- ***Plant Pathogens: The Prokaryotes*** by R.S. Singh
- ***Integrated Disease Management*** by R.S. Singh
- ***Diseases of Fruit Crops*** by R.S. Singh
- ***Fungicides in Plant Disease Control*** by P.N. Thapliyal and Y.L. Nene

- ***Diseases of Annual Edible Oilseed** Crops* Vol.-I by S.J. Kolte
- ***Diseases of Annual Edible Oilseed** Crops* Vol.-II by S.J. Kolte
- ***Diseases of Annual Edible Oilseed Crops*** Vol.-III by S.J. Kolte
- ***Diseases of Linseed & Fibre Flex*** by S.J. Kolte
- ***Castor Diseases & Crop Improvement*** by S.J. Kolte
- ***Plant Diseases of International Importance** Vol.I: **Diseases of Cereals & Pulses*** by U.S. Singh, A. N. Mukhopadhyay, J. Kumar, and H.S. Chaube
- ***Plant Diseases of International Importance** Vol.II: **Diseases of Vegetables & Oil Seed Crops*** by H.S. Chaube, U.S. Singh, A. N. Mukhopadhyay & J. Kumar
- ***Plant Diseases of International Importance** Vol.III: **Diseases of Fruit Crops*** by Drs. J. Kumar, H.S. Chaube, U. S. Singh & A. N. Mukhopadhyay
- ***Plant Diseases of International Importance** Vol.IV: **Diseases of Sugar, Forest & Plantation Crops*** A. N. Mukhopadhyay, J. Kumar, H.S. Chaube & U.S. Singh
- ***Pathogenesis & Host Specificity in Plant Diseases** Vol.I: **Prokaryotes*** by U. S. Singh, Keisuke Kohmoto and R. P. Singh
- ***Pathogenesis & Host Specificity in Plant Diseases** Vol. II: **Eukaryotes*** by Keisuke Kohmoto, U.S. Singh and R. P. Singh
- ***Pathogenesis & Host Specificity in Plant Diseases** Vol. III: **Viruses & Viroids*** by R. P. Singh, U.S. Singh and Keisuke Kohmoto.
- ***Aromatic Rices*** by R.K. Singh, U.S. Singh and G. S. Khush
- ***A Treatise on the Scented Rices of India*** by R.K. Singh and U.S. Singh
- ***Scented Rices of Uttar Pradesh & Uttaranchal*** by R. K. Singh and U.S. Singh
- ***Plant Disease Management : Principles & practices*** by H.S. Chaube and U.S. Singh
- ***Molecular Methods in Plant Pathology*** by R. P. Singh and U.S. Singh
- ***Soil Fungicides** Vol.-I* by A.P. Sinha and Kishan Singh
- ***Soil Fungicides** Vol.-II* by A.P. Sinha and Kishan Singh
- ***Experimental & Conceptual Plant Pathology** Vol.I: **Techniques*** by R.S. Singh, U. S. Singh, W.M. Hess & D.J. Weber
- ***Experimental & Conceptual Plant Pathology** Vol. II: **Pathogenesis and Host* Specificity** by R.S. Singh, U. S. Singh, W.M. Hess & D.J. Weber
- ***Experimental & Conceptual Plant Pathology*** Vol.III: **Defense** by R.S. Singh, U. S. Singh, W.M. Hess & D.J. Weber
- ***Seed Pathology***, 2 volumes by V.K. Agarwal
- ***Phytopathological Techniques*** by K. Vishunavat and S.J. Kolte
- ***Crop Diseases & Their Management*** by H.S. Chaube & V.S. Pundhir
- ***Seed borne diseases of crops & their management** by V.K. Agrawal & Y.L. Nene*
- ***Plant Pathogens: the Nematodes** by R.S. Singh*
- ***Disease of vegetables crops** by R.S. Singh*

- ***Introductory Plant Pathology*** *by H.S. Chaube & Ram Ji Singh*
- ***Seed Health Testing: Principles and Protocols*** *by Karuna Vishunavat*
- ***Fundamentals of Seed Pathology*** *by Karuna Vishunavat*
- ***Mushroom Production Technology*** *by R.P. Singh & H.S. Chaube*
- ***The Elements of Plant Virology: Basic concepts and practical class exercises*** *by S.J. Kolte & A.K. Tewari*

Books in Hindi:

- **सब्जियों के रोग**– जी0 एस0 दूबे, अमेरिका सिंह (1976)
- **फसलों के रोग** –ए0एन0 मुखोपाध्याय, आर0 ए0 सिंह (1976)
- **फलों के रोग**– पी0 एन0 थपलियाल, एस0 पी0 एस0 बेनीवाल (1976)
- **पौधों के रोग** –आर0 एस0 सिंह (1976)
- **कवकनाशी एवं पादप रोग नियंत्रण**– वाई0 एल0 नैन (1976)
- **फसलों के रोगों की रोकथाम**– संगमलाल (1984)
- **मशरूम उत्पादन तकनीकी**– आर0 पी0 सिंह, अशोक चौधरी, प्रदीप कुमार (1997)
- **मिलेट के रोग**–ए0 पी0 सिन्हा एवं जे0 पी0 उपाध्याय (1997)
- **सब्जियों के रोग**– एस0 एन0 विश्वकर्मा, एच0 एस0 चौवे एवं ए0पी0 सिन्हा (2003)
- **फलों के रोग** – एस0 एन0 विश्वकर्मा (2006)
- **सब्जियों के रोगों की रोकथाम** – एस0 एन0 विश्वकर्मा (2000)
- **बीज रोग विज्ञान–** वी0 के0 अग्रवाल (1999)
- **मक्का के रोग–** संगम लाल (1993)
- **धान के रोग** – आर0 ए0 सिंह एवं जे0 सी0 भट्ट (1995)
- **फसल–सब्जी–फल रोग, पहचान एवं प्रबन्ध** – योगेन्द्र सिंह एवं अखिलेश सिंह

Manuals:

- **Chemicals in Plant Disease Control** by Y.L. Nene, R.K. Tripathi, P.N. Thapliyal & S.C. Saxena (1974)
- **Management of Soil Borne Plant Diseases** by R.S. Singh (1980)
- **Biocontrol of Fungal Plant Disease** by A.N. Mukhopadhyay, H.S. Chaube, U.S. Singh & S.C. Saxena (1994)
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- **मृदा सौरीकरण–** एच0 एस0 चौबे एवं एस0 एन0 विश्वकर्मा
- **सेब के मुख्य रोग कीट एवं उनका समेकित प्रबन्धन–** के0 पी0 सिंह एवं जे0 कुमार
- **सब्जियों में समेकित नाशीजीव प्रबन्धन–** जे0 कुमार

RESEARCH

Research work in the department began since the inception of the University. With the addition of new programme and staff strength, the research activities got diversified encompassing, Ecology of soil borne plant pathogens, Epidemiology and Forecasting, Biological control and IPM, Molecular Biology and Population Biology, Seed Pathology, Fungicides, Nematology, Phytovirology, Phytobacteriology and Biology & Technology of Mushroom Production. The department has several research projects funded by national and international funding agencies. The department is guiding the research work at the regional station such as Bharsar, Kashipur, Lohaghat, Majhera and Ranichauri on pathological aspects. The scientists of the department have won many national and international awards.

The department is actively engaged in the research work on both fundamental and applied aspects in frontier areas of plant pathology. The plant protection technology developed by the department is being effectively communicated to the farming community of state of Uttaranchal. The department has to cater the needs of not only farmers of the plain but also of hills located at different altitudes. In hills crops, diseases and cropping practices vary a lot depending on altitudes and they are quite different from plain. This offers a big challenge to the Centre of Advanced Studies in Plant Pathology.

Significant Contribution

- Cause and control of Khaira disease of rice
- Development of selective media for isolation and enumeration of *Pythium* and *Fusarium*
- Mechanism of biological control in soil amended with organic matters
- Biology and characterization of legume viruses
- Ecology of soil – borne pathogens (*Fusarium, Pythium, Rhizoctonia solani, Sclerotium rofsii*)
- Mechanism of absorption, translocation and distribution of fungicides in plants
- Methods for quantitative estimation of fungicides like metalaxyl, organotin compounds, carbendazim etc.

- Hormonal action of fungicides
- Phenolics in Plant disease resistance
- Biological control with introduced antagonists
- Etiology & management of mango malformation
- Etiology and management of shisham wilt.
- Epidemiology and Genetics of Karnal bunt fungus
- Population biology of rice blast fungus, *Magnaporthe grisea*
- Mechanism of intra-field variability in *Rhizoctonia solani*
- Soil solarization
- Mushrooms – Development of strains, and production technologies
- Role of *Ps. fluorescens* in sporophores development of *A. bisporus*
- Compost formulation with Sugarcane baggase + Wheat Straw, 2:1 developed to reduce cost of cultivation of *Agaricus bisporus*.
- Developed chemical treatment (Formalin 15ml + Bavistin 0.5g/10kg compost) of long method compost to avoid the moulds in cultivation of *A. bisporus.*
- Recommended supplementation of substrate with 2% mixture of Neem cake + Wheat straw + Rice bran + Soybean meal for *Pleurotus* spp. cultivation.
- Standardized cultivation of *Auricularia polytricha* using sterilized wheat straw supplemented with wheat bran (5%).
- Standardized cultivation of *Lentinula edodes* with substrate popular sawdust.
- Systemic induced resistance in brassicae.
- Use of siderophore producing *Pseudomonads* for early fruiting and enhanced yield of *Agaricus bisporus.*


Lentinula edodes

- Use of *Pseudomonas fluorescens* for control of mushroom diseases caused by *Verticillium, Sepedonium, Trichoderma* and *Fusarium.*
- *Pleurotus sajor-caju and P. florida* recommended for commercial cultivation using soybean straw / Paddy straw / Wheat straw / Mustard straw.
- Standardized cultivation technology for *Hypsizygus almarius* using wheat straw supplemented with wheat bran.
- Standardized cultivation of *Calocybe indica* using wheat straw as a substrate with casing of FYM + Spent Compost + Sand (2:1:1).


Calocybe indica

- A relay cropping schedule developed for Tarai region of Uttaranchal: two crops *Agaricus bisporus* (Sept. - March), four crops *Pleurotus spp.* (Sept.- Nov. and Feb.,- April) and three crops of *Calocybe indica* (March-October).
- Developed two strains of *Agaricus bisporus,* Pant 31 and Pant 52, now included in multilocational testing under coordinated trials.

- Development and commercialization of seven hybrids of oyster mushroom.
- Associated with multilocational testing and release of the strains NCS-100, NCS-102, NCH-102 of *A. bisporus*.
- 120 mushroom species from different locations in Uttaranchal have been collected and preserved in the museum of the centre.
- Of the collected mushrooms five *Auricularia,* four species of *Pleurotus* and two species of *Ganoderma* have been brought under cultivation.

Ganoderma lucidum

- Developed / standardized technology for production of traditional value added mushroom products viz. 'Sev', 'Warian', 'Papad' and 'Mathri'.
- Isolated a high value cater pillar mushroom *Cordyceps sinensis* from high altitudes of Uttaranchal and analysed for antioxidative properties.

Cordyceps sinensis

MAJOR ACHIEVEMENTS

- Twenty seven wheat lines, combining better agronomic characteristics and resistance to diseases including Karnal bunt have been identified (Shanghi-4, BW 1052, HUW 318, Lira/Hyan'S' VUI'S', CUMPAS 88, BOBWHITE, SPRW 15/BB/Sn 64/KLRE/3/CHA/4/GB(K)/16/VEE/ GOV/AZ/MU, NI9947, Raj 3666, UP 1170, HS 265, HD 2590, HS317, PH 130, PH 131, PH 147, PH 148, PH 168, HW 2004, GW 188, MACS 2496, CPAN 3004, K8804, K8806, ISWYN-29 (Veery"S") and Annapurna).

- Foliar blight of wheat has now been assumed as a problem in Tarai areas of U.P and foothills of Uttaranchal. *Bipolaris sorokiniana* - *Dreschlera sorokiniana*, was found associated with the disease in this area. Karnal bunt of wheat caused by *Tilletia indica* Mitra, is widely distributed in various Western and Eastern districts of U.P while the North hills and Southern dry areas are free from the disease.
- Multiple disease control in wheat has been obtained by seed treatment with Raxil 2DS @ 1.5g/Kg seed + one foliar spray fungicide Folicur 250 EW (Tebuconazole) @ 500ml/ha, which controls loose smut, brown rust, yellow rust, powdery mildew and leaf blight disease very effectively.
- The mixture of HD 2329 + WH 542 + UP 2338 produced highest yield recording 11.67 per cent higher as compared to average yield of their components.
- Among new fungicides Raxil 2DS (Tebuconazole) @ 1.0, 1.5, 2.0 and 2.5g/kg seed, Flutriafol and Dividend @ 2.5g/Kg seed were found highly effective in controlling the disease. Raxil 2DS

@ 1.5g/Kg seed as slurry treatment gave complete control of loose smut.

- New techniques for embryo count and seedling count for loose smut, modified partial vacuum inoculation method of loose smut, creation of artificial epiphytotics of Karnal bunt, NaOH seed soaked method for Karnal bunt detection and detached leaf technique for screening against leaf blight using pathogen toxin developed.
- The major emphasis has been on the screening of maize germplasms to various diseases with special reference to brown stripe downy mildew, banded leaf and sheath blight and Erwinia stalk rot. A sick-plot has been developed to ensure natural source of inoculum. Efficient techniques for mass multiplication of inoculum and screening of germplasms have been developed to create epiphytotic conditions. The selected genotypes have been utilized for evolving agronomically adaptable varieties. Several promising hybrids and composites have developed and released following interdisciplinary approach.
- Studies on estimation of yield losses, epidemiological parameters on various economically important diseases of maize have been worked out to evolve suitable control measures and have been recommended to farmers in the region.
- Based on the survey and surveillance studies the information on the occurrence of various diseases in UP and Uttaranchal, a disease map has been prepared and monitored to finalize the out breaks of one or more diseases in a given area based on weather parameters. It will help the growers to be prepared to save the crop from recommended plant protection measures.
- An repository of >600 isolates of biocontrol agents developed at Pantnagar & Ranichauri. These isolates are suited for different crops & agro-ecological conditions.
- Standard methods developed for testing hyphal and sclerotial colonization.
- Isolate of *T. virens* capable of colonizing sclerotia of *Rhizoctonia, Sclerotium* and *Sclerotinia* isolated for the first time. It may have great potential.
- 16 new technologies related with mass multiplication and formulation of microbial bio-agents developed and are in the process of being patented.
- Several genotypes including SPV 462, SPV 475, SPV 1685, SPH 1375, SPH 1420, CSV 13, CSV 15, CSH 14, CSH 16, CSH 18, G-01-03, G-09-03, GMRP 91, RS 629, UTFS 45, UTMC 523 and AKR 150 have been identified with high level of resistance to anthracnose and zonate leaf spot diseases.
- Biocontrol agents *T. harzianum* and *P. fluorescens* have been found effective in increasing the growth of plants and reducing the severity of zonate leaf spot. *G. virens* and *T. viride* have been found most effective against anthracnose pathogen.
- The cause of Khaira as zinc deficiency was established for the first time and zinc sulphate +slacked lime application schedule was developed for the control of the disease
- Inoculation technique was developed to create “Kresek” phase in rice seedlings. Pre-planting root exposure technique in a suspension of 10^8cells/ml for 24 hrs gave the maximum “Kresek”. Root inoculation, in general was found better for development of wilt symptoms than shoot inoculation.

- A simple technique has been developed to detect the pathogen in and/or on seeds. The presence of viable pathogen has been demonstrated from infected seeds stored at room temperature up to 11 months after harvest.
- The disease is sporadic in occurrence often becomes serious in nature. Chemical control trials showed that the disease can effectively be controlled by giving 2-3 foliar sprays of streptocycline @ 15 g/ha.
- A number of new fungicides along with recommended ones and botanicals were tested against sheath blight. Foliar sprays with Anvil, Contaf, Opus, Swing and RIL F004 @ 2 ml/l and Tilt @ 1 ml/l were found highly effective in controlling sheath blight. Foliar sprays with Neem gold @ 20 ml /lit. or Neem azal @ 3ml/lit. was found significantly effective in reducing sheath blight and increasing grain yield.
- Foliar sprays with talc based formulations of the bioagents *(Trichoderma harzianum,* or *Pseudomonas fluorescence*, rice leaf isolates) were found effective in reducing sheath blight and increasing grain yield. Foliar sprays with the bioagents *(T.harzianum)* or *P. fluorescence)* given 7 days before inoculation with *R. solani* was highly effective against the disease.
- Seed or soil treatment with *T. harzianum or P. fluorescence* @ 2, 4 or 8 g/kg enhanced root and shoot growth and fresh and dry weight of rice seedlings.
- Seed treatment with fungorene followed by one spray of carbendazim (@ 0.05% at tillering at diseases appearance) and two sprays of Hinosan @ 0.1% at panicle initiation and 50% flowering was most effective and economical treatment in reducing the disease intensity and increasing the yield.
- For the first time, true sclerotia were observed in Kumaon and Garhwal regions at an altitude of 900 m above. True sclerotia have a dormancy period of approximately six months. Exposure of sclerotia to near ultraviolet radiation for an hour breaks the dormancy and increased germination.

- *Trichoderma* may reduce population of earthworm in vermicomposting during early days
- An repository of >600 isolates of biocontrol agents developed at Pantnagar & Ranichauri. These isolates are suited for different crops & agro-ecological conditions.
- Isolates of *T. virens* capable of colonizing sclerotia of *Rhizoctonia, Sclerotium* and *Sclerotinia* isolated for the first time. It may have great potential.
- Standard methods developed for testing hyphal and sclerotial colonization.
- 16 new technologies related with mass multiplication and formulation of microbial bioagents developed and are in the process of being patented.
- Effect of different physical factors and extracts on the germination of true sclerotia was studied. Maximum germination was observed at 25^0 C and at pH 6.0, in fluorescent light. Among the substratum, maximum germination occurred on moist sand. Soil extract was more favourable

than other extracts. The number of stipes and mature head formation was directly correlated with the size and weight of the sclerotia.

- The viability of the 3 propagules namely; conidia, pseudo and true sclerotia stored under different conditions showed that conidia remain viable from 2-3 months, pseudo- sclerotia from 4-6 months and true sclerotia up to 11 months at room temperature and under field conditions. True sclerotia buried at different depth (2.5 to 10 cm) in soil germinated well, but scleroita buried at 15 cm depth did not germinate and rotted.
- Discoloured grains of various types were grouped according to their symptoms. The fungi responsible for each type of symptoms were identified. Ash grey discolouration of glumes separated by dark brown band was caused by *Alternaria alternata* and *Nigrospora oryzae.* Spots with dark brown margin and ash grey centre by *Curvularia lunata* and *Alternaria alternata,* light yellow to light brown spots by *C. pallescens*, *Fusarium equiseti and N. oryzae,* Brown to black dot by *Phyllosticta oryzae* Dark brown to black spot and specks by *Drechslera victoriae, D. rostratum and D. oryzae, l*ight to dark brown glumes by *Sarocladium oryzae and D. oryzae,* and light to dark brown spots by *D. Australiense*.
- Rice varieties Manhar, Narendra 80, Saket 7, Ajaya, Bansmati, 385 showed higher incidence (34.1 to 41.8%) whereas Sarju 52, UPR 1561-6-3, Pusa 44, Jaya, Pant Dhan 10 and improved Sharbati exhibited lower (18.4-22.3%) incidence of seed discolouration. *Bipolaris oyzae* caused highest seed discolouration which is followed by *Fusarium moniliforme, curvularia lunata* and *Fusarium graminium* in all the test varieties.
- On the basis of the symptoms pattern and transmissibility of the pathogen through grafting and eriophyied mite (Aceria *cajani*), presence of foreign ribonucleic protein and nuclear inclusion like bodies in the phloem cell indicated the viral (RNA virus) nature of the pathogen of sterility mosaic of pigeon pea. The vector mite of the pathogen was found on lower surface of leaves of *Canavis sativus* and *Oxalis circulata* weeds in this area. Mild mosaic, ring spot and severe mosaic symptoms were observed in different as well as same cultivar. This observation reveals the presence of variation in the pathogen.
- Germplasm lines/ cultivars screened viz; ICP 14290, ICP 92059,ICP 8093, KPBR 80-2-2, PL 366, ICPL 371, Bahar, NP (WR) 15.were found resistan against Phytophthora stem blight.
- Some resistant donors for mungbean yellow mosaic virus have been identified i.e. UPU-1,UPU-2,UPU-3, UG-370, PDU-104, NDU-88-8, UG-737, and UG-774. The varieties thus evolved include PU-19, PU- 30, and PU-35., Manikya, resistant lines/cultivars identified: ML-62, ML-65, Pant M-4, Pant M-5, ML-131, NDM 88-14, ML-682, PDM-27, ML- 15, ML-803, ML-682 and 11/ 395 and for Urdbean leaf crinkle virus, SHU 9504, -9513,-9515, -9516, -9520, -9522, -9528, KU 96-1, UG 737 and TPU-4.
- Seed treatment with carbendazim (0.1%) followed by two prophylactic sprays of carbendazim (0, 05%) or Dithane M-45 @ 0.25% was found most effective in reducing disease severity of anthracnose disease. In early sown crop high disease severity was observed while in late

sown crop low disease severity was recorded. Inter cropping with cereals or pulses have no effect on anthracnose severity.

- Propiconazol 0.1%, carbendazim 0.1%, hexaconazol 0.1%, mancozeb 0.25% sprayed plots have low disease severity and high grain yield against Cercospora leaf spot.
- Studies on integrated management of wilt/root rot/collar rot showed that Seed treatment with fungicide alone or in combination with other fungicides/ bio agents were found effective. Among the fungicides seed treatment with Bavistin + Thiram (1:2), vitavax + Thiram (1:2), vitavax, Bavistin, Bayleton, Bio agent *Gliocladium virens* + Vitavax and *Pseudomonas fluorescence*) decreased the seedling mortality, improved germ inability, plant stand and yield.
- Eleven thousand germplasm lines/ breeding populations F_2, F_3, F_4 and F_5 generations were screened. Many germplasm/ accessions were found resistant/ tolerant to Botrytis gray mould viz; ICC 1069, ICC 10302, ICCL 87322, ICC 1599, - 15980, - 8529, ICCV 88510, E100Y (M) BG 256, BG261, H86-73, IGCP 6 and GNG 146.

- Lentil entries evaluated under sick plot for wilt/root rot/ collar rot diseases. The following lines were found promising viz; LL 383, PL 81-17, LH 54-8, DPL-58, DPL 14, Jawahar Massor- 3, DPL 112, IPL-114, L 4147 and Pant L 639.
- The promising germplasm lines/ cultivars are as follows: DPL 62, PL-406, L 4076, TL 717, E 153, IPL 101, IPL 105, PL- 639, LH 84-8, and Precoz .
- The field pea lines were found promising JP 141, Pant P-5, KFPD 24 (swati), HUDP 15, KFPD-2, HFP-4, P1361, EC-1, P-632, P 108-1, KPMR 444, KF 9412, DPR 48, T-10, KPMRD348, DDR13, IM9102, KFP 141 and KPMR 467 against powdery mildew and JP 141, Pant P-5, P 10, FP 141, KDMRD 384, HUDP-9, HUP-2 and T-10 were found promising against rust disease.
- Mid-September planting or early October planting of rapeseed-mustard has been found to escape from Alternaria blight (*Alternaria brassicae)* downy mildew (*Peronospora parasitica*) and white rust (*Albugo candida*) diseases as against mid and late October planting. In general high occurrence of the floral infection (staghead phase) of white rust and downy mildew during flowering period has been found to be associated with reduced period, i.e. 2-6 hours, of bright sunshine/day concomitant with the mean maximum temperature of 21-25^{0}C, the mean minimum temperature of 6-10^{0}C and higher total rainfall up to 166 mm. Bright sunshine hours /day has a significant negative correlation whereas total rainfall has a significant positive correlation with staghead development.
- All the three important foliar diseases of rapeseed-mustard could be effectively controlled by following integrated package of balanced N_{100} $P_{40}K_{40}$ application, early October sowing and treating the seed with Apron 35 SD @ 6g kg^{-1} seed followed by spray of mixture of metalaxyl +

mancozeb (i.e Ridomil MZ 72 WP @ 0.25%) at flowering stage and by spray of mancozeb or iprodione @ 0.2% at pod formation stage. In situations where Sclerotinia stem rot and / or powdery mildew appeared to be important in a particular crop season, a spray of mixture of carbendazim (0.05%) + mancozeb (0.2%) was found to give excellent cost effective control of the diseases with significant increase in seed yield of the crop.

- Among the botanicals, leaf extracts of *Eucalyptus globosus* (5%) and *Azadirchta indica* (5%) have been proved to exhibit greater antifungal activity against *A. brassicae* and *Albugo candida* and showed significant reduction in the severity of Alternaria blight and white rust diseases which was rated to be at par with mancozeb fungicide spray.
- Some abiotic chemical nutrient salts such as calcium sulphate (1%), zinc sulphate(0.1%) and borax (0.5%) and biocontrol agents such as *Trichoderma harzianum* and non-aggressive D pathotype of *A.brassicae* have been shown to induce systemic host resistance in mustard against aggressive "A" pathotype of *A. brassicae* and virulent race(s) of *A. candida.*
- The staghead phase in *B. juncea* has been investigated to be due to *A. candida* and not due *P. parasitica*. Tissues at the staghead phase become more susceptible to *P. parasitica* than normal tissues of the same plant.
- *B. juncea* genotypes (EC 399296, EC 399299, EC 399301, EC 399313, PAB-9535, Divya Selection-2 and PAB 9511), *B. napus* genotypes (EC 338997, BNS-4) and *B. carinata* (PBC-9221) have been shown to possess resistance to white rust coupled with high degree of tolerance to Alternaria blight. Reduced sporulation is identified to be the major component for slow blighting.
- *B. juncea* (RESJ 836), *B. rapa* (RESR 219) and *B. napus* (EC 339000) have been selected for resistance to downy mildew and for high yield performance. Total 52 genotypes of mustard representing at least 12 differential resistance sources, 23 lines of yellow sarson representing 6 differential resistance sources and 54 lines of *B. napus* representing 3 differential resistance sources to downy mildew have been identified.
- A new short duration (95-100 days) short statured (85- 96 cm) plant type of mustard strain 'DIVYA' possessing high degree of tolerance to Alternaria blight suitable for intercropping with autumn sown sugarcane and potato yielding with an average of 15-22 q ha^{-1} has been developed. This 'Mustard DIVYA' plant type is now recommended as a source for breeding more and more improved varieties of mustard as it has been proved to have good general combining ability for short stature characteristics.
- Seed treatment with mancozeb @ 0.2% + thiram @ 0.2% has been found to control seed, seedling and root rot diseases of groundnut. However seed treatment with thiram @ 0.2% + vitavax @ 0.2% has been found to control collar rot (*Sclerotium rolfsii*) of groundnut. Two sprays of carbendazim @ 0.05% have been found to give excellent control of early and late leaf spot (tikka disease) of groundnut.
- Mid September planting of sunflower was found to escape the occurrence of major diseases

like *Sclerotinia* wilt and rot, *Sclerotium* wilt, charcoal rot and toxemia. Severity of *Alternaria* blight was found to be negligible and did not cause any reduction in yield. The crop could be harvested by 15th December. The yield obtained was 16 q/ha.

- The average percent loss has been noted in the range of 50.6 to 80.7 percent due to Alternaria blight disease under Kharif conditions. However, the percent loss in oil has been shown in the range of 21.6 to 32.3. To control the disease, total 4 sprays of mancozeb @ 0.3% at 10 day interval have been found effective.
- A repository of about 5000 rice blast isolates was made from 30 locations in Indian Himalayas at Hill Campus, Ranichauri. Blast pathogen population from the region was analyzed using molecular markers and phenotypic assays. Most locations sampled and analyzed had distinct populations with some containing one or a few lineages and others were very diverse. Within an agroecological region migration appeared to be high. The structure of some populations could be affected to some extent by sexual recombination.
- *Magnaporthe grisea* isolates derived from *Eleusine coracana*, *Setaria italica* and *Echinochloa frumentaceum* collected from a disease screening nursery were cross compatible. The chromosome number of each isolate was found to be six or seven. Similarity of karyotypes was found among isolates with in a lineage though between lineages some variability was noticed. A remarkable similarity between karyotypes of *Eleusine coracana* and *Setaria italica* was observed. All of these isolates were fertile and mated with each other to produce productive perithecia. The existing data however showed no evidence of genetic exchange among host-limited *M. grisea* populations in Indian Himalayas.
- No strong relationship appeared between the number of virulences in a pathotyope and its frequency of detection. The frequency of virulent phenotype to a cultivar and susceptibility of that cultivar in the field did not correspond. The number of virulences per isolate was in general less than the number of virulences per pathotype, which indicated predominance of isolates from pathotypes with fewer virulences. There was a tendency for the pathotypes to have fewer virulences. The frequency of virulence among rare pathotypes was higher than common pathotypes against all the differential NILs, including two-gene pyramids. These rare pathotypes could be the potential source of resistance breakdown of the novel resistance genes.
- Blast resistant gene *Pi-2*(t) appeared to have the broadest and *Pi-1(t)* the narrowest resistant spectra. Compatibility to *Pi-2 (t)* gene did not appear to limit compatibilities with other resistant genes. Loss of avirulence to all the five major gene tested may carry a serious fitness penalty. Major gene *Pi-2* and gene combination *Pi-1,2* showed least compatibilities and hold promise in managing blast in the region. In the overall Himalayan population, gene combinations in general were effective at most locations. Combination of *Pi-1+2* genes was effective at most locations until the year tested. However, three gene pyramid [*Pi-1(t) + Pi-2(t)+Pi-4(t)*] resisted infection at all locations.

- It was inferred that the pathotype composition of the blast pathogen composition in the Indian Himalayas was very complex and diversifying the resistance genes in various rice breeding programmes should prove to be a useful strategy for disease management.
- A common minimum programme under bio-intensive IPM in vegetables in Uttaranchal hills was designed that is extended to over 2000 farmers from 20 villages in district Tehri Garhwal.
- Epidemiological considerations in the apple scab disease management led to the development of disease prediction models. Relation of degree-day accumulations to maturation of ascospores, and potential ascospore dose (PAD) were found to be useful for predicting the total amount of inoculum in an orchard thereby effectively improving apple scab management.
- Out of 71 genotypes tested against red rot caused by *Colletotrichum falcatum*, four genotypes viz; Co Pant 92226, Co Pant 96216, Co Pant 97222 and CoJ 83 were found resistant and another 24 exhibited fairly good tolerance.
- Seed treatment with Thiram + Carbendazim (2:1) @ 3g/kg seed or Vitavax 0.2% controlled the seed and seedling rots and improved the seedling emergence without any adverse effect on the nodulation and invariably yield were increased. Seed treatment with *Trichoderma harizianum*, *T. viride* or *Pseudomonas fluorescens* @ 10g/kg controlled seed and seedling rots and increased plant emergence.
- Purple seed stain disease can be effectively controlled by seed treatment with thiram + carbendazim (2:1) @ 3 g/kg seed followed by two sprays of benomyl or Carbendazim @ 0.5 kg/ha.
- Rhizoctonia aerial blight can be effectively controlled by two sprays of carbendazim @ 0.5 kg/ha. Seed treatment with *T. harzianum* or *Pseudomonas fluorescens* 10g/kg seed + soil treatment with pant Bioagent-3 mixed with FYM @50q/ha followed by two sprays of *T. harzianum* @ 0.25% reduced the disease severity of RAB.
- Pod blight and foliar diseases caused by *Colletrotichum dematium* var *truncatum* could be effectively controlled by the use of carbednazim 0.05%, Mancozeb 0.25%, Copperoxychloride 0.3%, Thiophanate methyl 0.05%, Chlorothalonil 0.25%, Hexaconazole 0.1% and Propiconazole 0.1%. First spray should be given as soon as disease appear and second spray after 15 days of first spray.
- Rust disease could be effectively controlled with three sprays of Benomyl 0.05%, Mancozeb 0.25% or Zineb 0.25%, at 50, 60 and 70 days after sowing. Varieties Ankur, PK-7139, PK-7394, PK-7121, PK-7391 were resistant.
- Charcoal rot disease can be effectively controlled by seed treatment with *Trichoderma harzianum* @ 0.2% + vitavax @ 0.1%.
- Pre-mature drying problem Soybean can be minimized by seed treatment with carbendazim +

Thiram (2:1) @ 3g/kg seed followed by two sprays with carbendazim, mancozeb and Aureofungin. Varieties PSS-1, PS-1042, PK-1162, PK-1242 and PK-1250 were found to be superior for premature drying problem.

- Integrated disease management (IDM) modules based on combined use of cultural practices, fungicides for fungal disease, insecticide for virus disease and host resistance were evaluated against RAB and Soybean yellow Mosaic virus diseases.
- Bacterial pustules can be successfully controlled by two sprays at 45 and 55 days after planting with a mixture of Blitox-50 (1.5 kg/ha) + Agrimycin-100 (150g/ha) or streptocycline (150 g/ha) + copper sulphate (1kg/ha).
- Soybean yellow Mosaic can be very effectively controlled by four sprays with oxymethyl demoton @ 1l/1000 lit/ha at 20, 30, 40 and 50 days after planting. Soil application with Phorate 10G @ 10 kg/ha and Furadan 3G @ 17.5 kg/ha controlled the disease. Varieties PK-1284, 1251, 1259, 1043, 1225, 1303, 1314, 1343, 1347, PS-1042 PS-564, 1364 were identified as resistant to Soybean yellow Mosaic virus.

EXTENSION

The scientists also participate in the farmers contact programme as well as practical trainings at different levels including those of IAS and PCS officers, Extension workers, Agricultural officers, Farmers, Defense Personnels etc. The Scientists of the department also actively participate in the trainings organized under the T&V programme for the benefit of farmers/State level Agricultural Officers. Two Professors (Extension Pathology) and crop disease specialists are deputed to “Help Line Service” started recently by the University under Agriculture Technology Information Centre (ATIC). The telephone number of help line services is 05944-234810 and 1551. Technology developed by the centre is regularly communicated to the farmers of the 13 districts of Uttaranchal State through the extension staff (Plant Protection) of both university and state agriculture and horticulture departments posted in all districts of the state. The radio talks and TV programme are delivered. Popular articles and disease circulars are published regularly for the benefit of the farmers.

UP-GRADATION TO CENTRE OF ADVANCED STUDIES

In view of the outstanding quality of teaching, research and extension work being carried out in the Department, ICAR in 1995 upgraded the department to the status of the **Centre of Advanced Studies in Plant Pathology (CAS)** and now has been upgraded to **Centre of Advanced Faculty Training (CAFT).** Major mandate of the CAFT is to train scientific faculty from all over the country in important and innovative areas of Plant Pathology. So far 25 trainings, with 512 participants from 25 states, have been held The CAS was awarded by the education division, ICAR on August 14, 1998 a certificate of appreciation in commemoration of Golden Jubilee year of independence (1998) for

organizing the programmes for human resource development and developing excellent instructional material. The progress report CAS/CAFT in Plant Pathology is as follows:




Trainings Held

1. Recent advances in biology, epidemiology and management of diseases of major kharif crops (Sept. 19- Oct. 12, 1996)
2. Recent advances in biology, epidemiology and management of diseases of major rabi crops (Feb. 25 –March 17, 1997)
3. Ecology and ecofriendly management of soil-borne plant pathogens (Jan 12 – Feb. 02, 1998)
4. Advanced techniques in plant pathology (Oct. 12 – Nov. 02, 1998)
5. Recent advances in detection and management of seed-borne pathogens (March 10-30, 1999)
6. Recent advances etiology and management of root-rot and wilt complexes (Nov. 26 – Dec. 16, 1998)
7. Integrated pest management with particular reference to plant diseases: concept, potential and application (Nov. 23 –Dec. 13, 2000)
8. Recent advances in research on major diseases of horticultural crops (March 01-30, 2001)
9. Recent advances in plant protection technology for sustainable agriculture (Nov. 19 –Dec. 09, 2001)
10. Plant diseases diagnosis: past, present and future (Feb. 13, - March 05, 2002)
11. Chemicals in plant protection: past, present and future (Jan. 28 – Feb. 17, 2003)

12. Eco-friendly management of plant diseases of national importance: present status and research and extension needs (Nov. 10-30, 2003)
13. Ecologically sustainable management of plant diseases: status and strategies (March 22-April 11, 2004)
14. Disease resistance in field and horticulture crops: key to sustainable agriculture (Dec. 10-30, 2004)
15. Regulatory and cultural practices in plant disease management (Dec. 03-21, 2005)
16. Crop disease management: needs and outlook for transgenics, microbial antagonists and botanicals (March 21 – April 10, 2006)
17. Soil Health and Crop Disease Management (December 02-22, 2007)
18. Role of Mineral Nutrients and Innovative Eco-friendly Measures in Crop Disease Management (March 22- April 11, 2007)
19. Plant Disease Management on Small Farms (January 03-23, 2008)
20. Seed Health Management for Better Productivity (March 28 to April 17, 2008)
21. Recent Advances in Plant Disease Management (Dec. 13, 08 to Jan. 02, 09)
22. Recent Advances in Biological Control of Plant Diseases (March 20 - April 09, 2009)
23. Plant Pathology in Practice (March 22 to April 11, 2010)
24. Climate change, precision agriculture and innovative disease control strategies (March 23 to April 12, 2011)
25. Quality Management and Plant Protection Practices for enhanced competitiveness in agricultural export (November 12 to December 02, 2011)

Sl. No.	State	Total	Sl. No.	State	Total
1.	Andhra Pradesh	13	14.	Maharashtra	38
2.	Arunachal Pradesh	01	15.	Manipur	01
3.	Assam	13	16.	Meghalaya	01
4.	Bihar	23	17.	Nagaland	01
5.	Chattishgarh	08	18.	Orissa	13
6.	Gujarat	42	19.	Punjab	05
7.	Haryana	04	20.	Rajasthan	43
8.	Himanchal Pradesh	38	21.	Sikkim	01
9.	Jammu & Kashmir	32	22.	Tamil Nadu	10
10.	Jharkhand	05	23.	Uttar Pradesh	67
11.	Karnataka	22	24.	Uttarakhand	80
12.	Kerla	05	25.	West Bengal	18
13.	Madhya Pradesh	28	26.	--	--
Total = 512					

INFRASTRUCTURE

- Wheat Pathology Lab. – General Path, Epidemiology, Toxin, Tissue Culture
- Maize Pathology Lab. – General Plant Pathology, Bacteriology
- Rice Pathology Lab. – General Plant Pathology
- Ecology and Vegetable Pathology Lab. – Ecology, Histopathology, Biocontrol, Nematodes
- Soybean Path. Lab.– General Plant Pathology, Fungicides
- Oil Seed Path. Lab.– General Pl. Path., Tissue, Culture, Histopathology, Toxins
- Pulse Path. Lab. – General Pl. Path., Phytovirology
- Seed Path. Lab. – General Path, Seed Borne diseases
- Biocontrol Lab. – Biocontrol & IPM
- Molecular Pl. Path Lab. – Population biology & host- pathogen interaction
- Mushroom Research – Research & training
- Glass houses – 3
- Polyhouses – 3
- UG Practical Lab – 1
- PG Lab – 1
- Training Hall – 1
- Conference Hall – 1
- Office – 1

Huts for Mushroom Production

OLD GLASS HOUSE RENOVATED



New Screen House Constructed

Research Project (on going)

- Programme Mode Support in Agrobiotechnology **(DBT)**
- Translational Research Centre on Biopesticides **(DBT)**
- All India Coordinated Research Project on Biological Control **(ICAR)**
- All India Coordinated Wheat and Barley Improvement Project **(ICAR)**
- All India Coordinated Rice Improvement Project **(ICAR)**
- Cereal Systems Initiative for South ASIA (CSISA) Objective 3 **(IRRI)**
- Chitosan/Copper-Nanoparticles and Biopesticides for Knowledge-Based Plant Protection **(DBT)**

- Large Scale Demonstration of IPM Technology through KVKs in Network Mode **(HTMM-I)**
- All India Coordinated Chickpea Improvement Project **(ICAR)**
- All India Coordinated Pigeonpea Improvement Project **(ICAR)**
- All India Coordinated MullaRP Improvement Project **(ICAR)**
- Screening of Chickpea Germplasms/Lines against BGM Disease (**NBPGR)**
- All India Coordinated Soybean Improvement Project **(ICAR)**
- All India Coordinator Research Project on Rapeseed & Mustard **(ICAR)**
- All India Coordinated Research Project on Seed Technology Research (NSP) **(ICAR)**
- DUS Test Centre for Implementation of PVP-LEGISLATION for Forage Sorghum at Pantnagar **(ICAR)**
- Seed Production in Agriculture Crops and Fisheries (Mega Seed Project) in Seed Technology Research **(ICAR)**
- All India Coordinated Potato Improvement Project **(ICAR)**
- Pest risk assessment of potato crop in Kumaon Region of Uttarakhand **(HTMM-I)**
- All India Coordinated Maize Improvement Project **(ICAR)**
- All India Coordinated Vegetable Improvement Project **(ICAR)**
- All India Coordinated Sugarcane Improvement Project **(ICAR)**
- All India Coordinated Sorghum Improvement Project **(ICAR)**
- All India Coordinated Mushroom Improvement Project **(ICAR)**
- Demonstration of Existing Mushroom Production Technologies **(HTMM-I)**
-

Total Budget Outlay – > 1000 lakhs

Research Areas – Biological Control, IPM, Shisham wilt, Soil solarization, Population Biology, Seed pathology, Mushroom etc.

Publication:

1.	Books	-	56
2.	Research Bulletins	-	20
3.	Research Papers	-	>1200
4.	Conceptual / Review articles	-	>130
5.	Chapters contributed to book	-	>150
6.	Extension literature (Hindi – English)	-	over (200)
	Annual Review of Phytopathology	-	02

Recognition and Awards:

- UNO (Rome) – Dr. Y. L. Nene
- Prof. M. J. Narisimhan Academic Award (IPS) 5

- Jawahar Lal Nehru Award (ICAR) 2
- Pesticide India Award (ISMPP) 7
- P. R. Verma Award for best Ph. D. Thesis (ISMPP) 2
- Other (Hexamar, MS Pavgi, Rajendra Prasad etc.) >20
- Uttaranchal Ratana 2
- Education Award 2004-05" for his book "फलों के रोग" by the Ministry of Human Resource Development, GOI 01

Professional Societies and our Share:

Indian Phytopathological Societies

Presidents – 3

Zonal Presidents – 3

Indian Society of Mycology & Plant Pathology –

Presidents – 3

Vice Presidents – 1

Indian Soc. Seed Technology

Vice Presidents - 3

Science Congress

President (Agriculture Chapter) - 1

National Academy of Agricultural Sciences

Fellows - 3

Future Strategies:

Teaching: Introduction of new courses

- Methods in Biological Control
- Plant disease and national importance
- Integrated plant disease management
- Molecular plant pathology
- Advances in mushroom production

Research thrust:

- Biological control & ICM (IPM + INM) in different crops/cropping systems
- Disease management under organic farming
- Microbial ecology
- Green chemicals
- Population biology of pathogens (including use of molecular tools)
- Induced resistance
- Exploitation of indigenous edible and medicinal mushrooms

Human Resource Development

Degree awarded

M.Sc.	313
PhD	176

Trainings organized	No.	Persons trained
Summer schools (ICAR)	5	136
Summer training (DBT)	1	24
International training (IRRI)	1	11 (8 countries)
Under CAS/CAFT	25	512

Persons training under SGSY on Mushroom Production 1785

Out of above > 750 persons have started mushroom cultivation

Future Goal:

Ecologically sustainable management of plant diseases to ensure both food security & safety through education, research & extension

Teaching Plant Pathology in India

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Plant Pathology in India began with the establishment in 1905 of the Indian (then imperial) Agricultural Research Institute at Pusa, Bihar (now at new Delhi) and the appointment of E.J. Butler (late Sir Edwin) as the first Imperial Mycologist. The credit for laying the foundation of plant pathology goes to him, and he may be called the "father of Indian plant pathology." Before he departed from India he published in 1918 a book on 'Fungi and Diseases in Plants' which remains a classic on the subject.

The first Indian universities that were established in 1857 at Calcutta Madras, and Bombay, emphasized taxonomy of fungi. Plant pathology as a University Science became established at Luck now, Allahabad and Madras Universities (founded in 1921, 1887 and 1857, respectively), only in the 1930s. There are now 46 Agricultural universities, each with a plant pathology department. Work on plant pathology is now also carried out at various State Departments of Agriculture and many other institutions.

Three plant disease epidemics stimulated greatly the growth of plant pathology in India. These were the great Bengal famine of 1942 caused by a *Helminthosporium* blight of rice, the severe wheat shortage in Madhya Pradesh during 1946 and 1947 due to wheat rust, and the red rot epidemic in 1938-42 on sugar cane in Uttar Pradesh and Bihar States. Losses from diseases generally are enormous. Annual losses due to wheat rust alone have been estimated to be about 0.3 million tons of wheat worth about 32.2 million rupees. The total overall decrease in production of food grains due to fungal diseases has been considered to be about 5 million tons a year.

The increasing importance of plant pathology led to the foundation of the Indian Phytopathological Society in 1947 by B.B. Mundkur under the chairmanship of S.R. Bose. Initially there were 20 members; now the total is 1095 in India and abroad. In addition there are 340 subscribers to the Society journal.

The Indian (then Imperial) Council of Agricultural Research was established to promote, guide, and coordinate agricultural and animal husbandry research. Later, education and development work were also brought within the scope of the Council, which operates numerous institutes over the country on various crops. Recently under the leadership of the Indian Council of Agricultural Research, multidisciplinary all- India Coordinated Research Projects have been drawn up on various crops like rice, maize, cotton, wheat , fruits, etc. with an emphasis on plant pathology.

Dasgupta presented in 1958 the history of mycology and plant pathology in India, including Burma and Ceylon. Since it included a complete review of the literature it is extremely useful to research workers in plant pathology. Raychaudhuri dealt in 1967 with the development of plant pathological research, education and extension work in India. We will here highlight in historical

perspective the work done on important developments in plant pathological research.

Diseases Caused by fungi

E.J. Butler stayed at the Indian Agricultural Research Institute for 16 years (1905-1921) and established a strong school of mycology and plant pathology. His book, published in 1918, served as the major source of literature and inspiration to budding plant pathologists. With it as a base, Mundkur wrote in 1949 a smaller edition of *Fungi and Plant Diseases,* which was revised by Chattopadhyay in 1967.

Cereal rust received attention in India as early as 1907 when Milligan reported a heavy outbreak of rust on wheat in Punjab. Studies on the epidemiology of rusts and methods of their control comprise some of the most important contributions to plant pathology carried out in India. Mehta initiated in 1929 a series of experiments on the annual recurrence of black stem rusts on wheat in India, and published his results in a monograph in 1948 he showed that *Berberis* and other alternate hosts do not play any significant role in the perpetuation of wheat rusts in India, and that there is no local source of infection to account for the recurrence of rusts in the plains where the intense summer heat destroys all the rust inoculum of the preceding season. He showed that the main source of inoculum responsible for the fresh infection in the plains is derived from rust infection on the hills, where the crop is grown early. As a result of extensive surveys made periodically all over the wheat-growing areas of India, it was found that the black stem rust, which survives in the Himalayas, is not an important source of infection; the immense bulk of inoculum comes from the south (Nilgiri and Pulney hills).

Certain newer diseases of wheat have come into prominence in recent years because of new agricultural practices, such as extensive use of fertilizer intensive irrigation, and use of the new high yielding varieties. Leaf blight of wheat causd by *Alternaria triticina* is one such example. Mitra recorded *Tilletia indica* a new bunt (Karnal bunt) on wheat. The diseases was thought, erroneously to be soil borne . Later studies showed that it was air borne and the infection was not systemic .

The most important disease of rice in India is the *Helminthosporium* leaf spot caused by *H. oryzae.* The occurs endemically almost every year and was responsible for the severe famine conditions in Bengal in 1942. The nature and extent of damage caused by this disease were investigated and trials laid for controlling the primary seed-borne infection.

Green ear disease is serious on bajra (*Pennisetum typhoides).* Chaudhuri in 1931 first showed that the *oospores* of the pathogen, *Sclerospora graminicola* in the soil were responsible for its propagation. Artificial infection of the host could be accomplished only under very humid conditions .

Red rot (*Colletotrichum falcatum)* caused enormous loss to the sugar cane crop in India. It was first studied by Butler & Khan at Pusa in 1913. infection was found to occur through seed soil and irrigation water.Simple practical schedules for its control were suggested and the disease is now totally controlled by a hot air treatment of the setts .

Butler first described the smut disease of sugar cane caused by Ustilago sacchari. The mode of infection life history and method of perpetuation of the pathogen have been investigated.

A monograph on potato disease was written by Butler in 1903. Dastur reported that potato blight due to *Phytophthora infestans*, though uncommon in the Indian plains is found on the hills and caused severe damage to crops grown at an elevation of 6000 feet and above. Late blight was subsequently found to occur in the plains also. Dastur described tow new diseases of potato: leaf rot caused by a species resembling P. parasitica and tuber rot caused by a new species P. himalayensis.

Malformation is a devastating and somewhat mysterious disease of mango (Mangifera indica). During the last six decades different workers have attributed it to different causes: nutritional imbalance virus eriophyid mites etc. Affected shoots from mango trees recently have yielded Fusarium moniliforme (=Gibberella fujikuroi) which reproduces the disease in healthy inoculated seedlings grown in the glasshouse and kept free from mites . The disease has recently been shown to be systemic in branches and in preliminary trials good results have been obtained with benlate and aphidan for control of this malady. It is suggested that a judicious combination of pruning and application of insecticides fungicides and growth regulators may prove effective in controlling the disease.

Strong schools for fundamental pathology, especially the biochemistry of host parasite interaction were established at Luchnow and Madras Universities under the leadership of S.N. dasgupta and T.S. Sadasivan respectively. Dasgupta studied the role of enzymes in pathogenicity a general high metabolic rate and higher level of several enzymes were shown in virulent stains . Sadasivan's school developed the concept of vivotoxins and worked out the mechanism of cotton wilt caused by Fusarium wasinfectum. The production of fusaric acid by F. vasinfectum as a vivotoxin has been demonstrated . It was shown that iron although present in sufficient quantity in a living system may be bound up with fusaric acid as a chelate and therefore unavailable to the host plant A correlation existed between the amount of fusaric acid produced in vivo and the amount of heavy metals chelated. Further investigations revealed that chelation of zinc could also be one of the causes favoring wilt .

Research in forest pathology was initiated by Bagchee at the Forest Research Institute, Dehra Dun in the Himalayas. He reviewed the work done on the coniferous rusts, root and stem rotting fungi canker pathogens nursery diseases, timber diseases and the ecology and habits of forest fungi. He also listed rust and polypores attacking forest trees. The principal diseases of oak in India were also studied.

Some of the historical events in the use of fungicides should be mentioned. In 1885 Ozanne first used a fungicide in India for control of a crop disease when he used copper sulphate against sorghum smut. Lawrence used Bordeaux mixture for the first time in 1904 against Cercospora leaf spot of groundnut. Coleman claimed control in 1915 of Phytophthora omnivore var arecae on arrecanut with Bordeaux mixture plus resin. Cotton anthracnose was controlled by seed

dressing with an organomercurial fungicide after delinting the seed with sulphuric acid . Narasimhan suggested in 1930 the use of linseed oil in Bordeaux mixture for improving coverage and tenacity.

Wide use of antibiotics for the control of fungal diseases of crop plants is fairly new in India. Lately, Hindustan Antibiotics has taken a leading role in the commercial manufacture of antibiotics and one of their products that has been used extensively as a seed dressing a spray on standing crops and a post harvest dip is aureofungin.

G.S. **Kulkari**, student of Butler, generated detail information on downy mildew and smut of jowar and bajra .

S.L. Ajrekar studied wilt disease of cotton, sugarcane smut and ergot of jowar.

Karam Chand Mehta (1930-1942) of Agra had contributed lot to Plant Pathology of India .He first joined Agricultural College as demonstrator at Kanpur. His outstanding contribution in the discovery of the life cycle of stem rust of wheat in India and reported that barberry, an alternate host, does not play any role in perpetuation of the rust fungus in India.

Raghubir Prasad (1907-1992) trained under K.C.Meht , contributed to the identification of Physiological races of cereal rusts and life cycle of linseed rust.

L.M. **Joshi a**t IARI conclusively studied various aspects of wheat rusts viz., chief foci of infection of rusts, dissemination of rust pathogens in India.

S. Nagaraja and L.M. **Joshi** developed most useful **mathematical models i 1978 to predict appearace of stem a d leaf rust of wheat.**

Manoranjan Mitra was considered s one of the most critic l plant pathologist worked on *Helminthosporium* .He first reported Karnal bunt of wheat in 1931 from Karnal in Haryan .

B.B. **Mundkur** was the second mycologist trained under Butler and worked with Mehta and Mitra .He worked on control of cotton wilt by using resistant varieties and became successful in reducing yield loss in Maharashtra .His significant contribution is the establishment of Indian Phytopathological Society (IPS) in 1948 with its journal *Indian Phytopathology* .In the same year, he published text book ***Fungi and P ant Diseases*** which was the second book of Plant Pathology after the classic book of Butler.

S.R. **Bose** was taxonomist, mainly worked on the classification of Polyporaceae and isolated “polyporin ” from *Polyporus* .

M.J.Thirumalachar created 20 new generand 300 new species of fungi, monographed genera of Uredinales of the world and Ustilaginales of India . **M.J.Thirumalachar** Works on fund mental plant pathology, especially the biochemistry of host-parasite relationship were started t Lucknow and Madras (Chennai) lead by Sachindra Nath **Dasgupta** (1904-1990) and T.S.**Sadasiva** (1913-2001), respectively.

Similarly many Hyphomycetes particularly *Fusarium* were el borated by **C.V.Subramania** in 1971.

Dr. Dasgupta initiated the works on leather mycology, paper pulp mycology and predacious fungi.

Dr. Sadasiva’s school developed the **concept of vivotoxin a**nd reported the production of fusaric

acid by *Fusarium vasinfectum* that causes wilt diseases in cotton.

T.S. **Ramakrishnan**, mycologist to Madras Government cultivated ergot diseased rye for toxin production.**Ramakrishnan** published two books entitled *Diseases of Millets* (1963) and *Diseases of Rice* (1971).Renowned plant pathologists viz., **G Rangaswami and R.Ramakrishnan** were his students.

Teaching of plant pathology as course was **started at University of Calcutta** ,**Bombay** and**Madras** in 1857 where only fungal taxonomy was emphasized.

Plant Pathology as **science was started in 1930 at University of Allahabad** ,**Lucknow and Madras.**

Agra University had introduced one post-graduate programme in plant pathology in Govt. Agricultural College, Kanpur in 1945.

Diseases Caused by Viruses

Plant viruses did not receive much attention in India until about three decades ago though one of the earliest records in the country is the spike disease of sandalwood, first reported by Coleman in 1917 to be a graft transmissible virus disease, but now know to be caused by a mycoplasma .

One of the first diseases to be investigated in India in the late thirties was tobacco leaf curl caused by a virus transmitted by the whitefly Bemisia tabaci. The virus vector relationship was studied and the virus has been shown to have a very wide host range including tomato papaya sannhamp chilli and a number of weeds and ornamental plants .

The next two decades were mostly devoted to investigations on dissemination and control of a number of virus disease of economic crop plants such as sugar cane mosaic , stenosis or small leaf of cotton, yellow vein mosaic of bhindi , tomato leaf curl, Katte disease of small cardamom papaya mosaic and leaf curl and virus diseases of temperate fruits . The investigations mostly concerned the vectors and sources of resistance. As a result, resistant varieties were reported for several viruses and other sourece of resistance in wild species such as Carica cauliflora for papaya mosaic , Abelmoschus manihot var. pumgens for yellow vein mosaic of bhindi , Lycopersicon peruvianum for tomato leaf curl varieties Ichinose and Kairyonezumegaishi of Morusalba and Oshimasho and Kosen of M. Latifolia for mulberry mosaic . Whitefly, Bemisla tabaci Gen was found to be an effective vector of a number of virus diseases of crop plants and to carry several viruses simultaneously .

During the last decade a large number of virus diseases affecting cereals legumes and plantation crops such as cardamom citrus and coconut have been studied. Fundamental problems such as purification morphology of virus particles serology, tissue culture, inhibition and virus vector relationships have received increasing attention.

A notable feature of theses findings is the elucidation of the cause of some serious diseases of complex etiology such as citrus die back, coconut root wilt, and sandal spike. The citrus die back was shown to be caused by a complex in which greening disease 9now shown to be due to a

mycoplasma transmissible by psylla, Diplodia natalensis, Curvularia tuberculata and Fusarium sp.) Plays a major role. The coconut root wilt which has seriously affected the economy of the coconut industry in South India has been associated with a rod shape virus and the sandalwood spike with a mycoplams .

Plant virus research in India was started particularly at IARI, New Delhi under the leadership of **R.S**. **Vasudeva** (1905-1987), **S.P. Raychaudhury** (1916-2005) and **Anupam Varma** .

Y.L. **Nene's** contributions have been well remembered particularly the **viral diseases of pulses** and the '**Khaira'** disease of rice caused by Zinc deficiency. He wrote the book "**Fungicides in Plant Disease Control".**

Plant Bacteriology

Plant Bacteriology in India got a shape with the effort of **Makanj Kalyanji Patel** (1899-1967).

Makanj Kalyanji Patel established a school of Plant Bacteriology at College of Agriculture, Pune and first described new species *Xanthomonas campestris* pv.*uppali* in 1948 from the host *Ipomea muricota* .He described more than 30 bacterial diseases from India.

V.P. **Bhide** and **G**. **Rangaswami** also contributed their pioneering works to the phytobacteriology of India.

D.N. **Srivastava** (1925-2000) is mostly remembered for his tremendous contribution on bacterial blight of rice.

M.K. **Hingorani** reported bout the complex nature of ***tundu*** disease of wheat caused by bacterium and nematode in 1952 and also he confirmed the c us l gent of ring disease of pot to s *Pseudomonas* (=*Ralstonia*)*solana erarum* .

J.P. Verma (1939-2005) contributed many valuable findings on bacterial blight disease of cotton.

Role of Post Harvest Handling Operations and Machines in Maintaining Seed Quality

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Introduction

Seed is a living product that must be grown, harvested and processed correctly to maximize its viability and subsequent crop productivity. For the yield potential of any variety to be realized, good quality seed must be sown. Good quality seed can increase yields by 5-20%. The extent of this increase is directly proportional to the quality of seed that is being sown. Seed quality can be considered as the summation of all factors that contribute to seed performance. The seeds are processed to remove impurities, classified into size for planting, as overcome by the separation of damaged seeds or damaged and to apply the substance of health treatment. Seed processing is applied by the seed industry, through some operations in order to submit batches of seed to the producer. The objectives of the processing can include removing a wide range of materials which makes them unacceptable for use, thus ensuring the supply of seeds destined for the production of the next generation of a particular item.

Role of Post Harvest Handling Operations

Post harvest handling is the stage of crop production immediately following harvest, including cleaning, grading, sorting, drying, packaging and transportation etc. The instant crop is removed from the ground, or separated from its parent plant, it begins to deteriorate. Post harvest treatment largely determines final quality whether a crop is sold for fresh consumption or used as an ingredient in a processed food product. The main purpose of seed processing is to minimize the qualitative and quantitative deterioration of the material after harvest and the primary purpose of storing seeds is to save seed from one season to the next, but farmers and seed companies often find it useful or necessary to store seeds for at least two to three years, and sometimes longer. Seed processing includes all steps from preparation, once harvested for subsequent storage, to marketing. That efficient management of this process will depend on the final quality of the seed, this being a fundamental tool for increasing food production at satisfactory levels.

There are several reasons for this:

1. Seed yields and seed quality (germination and vigor) may be unpredictable due to growing conditions.
2. Market demand for certain crops may vary significantly from one year to the next.

Post Harvest Processing Methods

The purpose of processing is to remove undesirable materials from field-run seed. Quality control should be concerned with three phases:

a. Removing undesirable materials

b. Preventing contamination

c. Maintaining lot identity

Conditioing and precleaning:

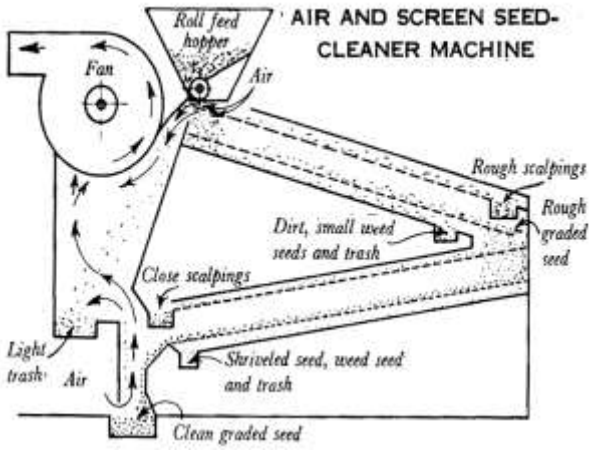
During this operation, seeds are moved through machines which remove material to improve seed purity, germination, or palatability. Processing operations can be divided into several steps in a specific sequence.

Receiving seed: into the processing plant. Seed may then go into storage for later processing, or go directly into processing.

Cleaning, grading and sorting

Cleaning and grading are the first and most important post harvest operations undertaken to remove foreign and undesirable materials from the threshed crops and to separate the grains/products into various fractions. The crops after harvesting and threshing contain organic and inorganic impurities like straw, chaff, weed seeds, iron pieces, stones, mud etc. Seeds with impurities fetch lower prices. Presence of foreign matters increases the bulk hence increases cost of handling and transportation. Threshed seed contains all kinds of trash. This trash can be vegetable, such as chaff, straw, empty grains and foreign seed as well as mineral materials such as earth and stones. Seed should be cleaned as soon as possible after harvesting and certainly before storage. The simple traditional cleaning method is winnowing, which uses wind or a fan to remove the light elements from the grain.

Mechanical winnowers that incorporate a fan and several superimposed reciprocating sieves or screens are now used. Where combine harvesters are used, there is a trend towards using large capacity centralized seed cleaners. These are normally equipped with a series of vibrating sieves.



Seed Cleaner

Seed processing can be divided into two methods

1. Dry Processing

Dry processing involves harvesting seeds that has already matured and dried within the seed bearing portion of the plant. Examples of dry processed seed plants include beans, broccoli, corn, lettuce, okra, onions, sunflower, and turnips.

2. Wet Processing

Wet processing is used when the mature seed is enclosed within a fleshy fruit or berry. Examples of wet processed seed plants include cucumbers, melons, and tomatoes.

A mixture of seeds can be separated on the basis of difference in length, width/thickness, specific gravity, surface texture, drag in moving air, colour, shape, electrical conductivity and magnetic properties.

Grading of cleaned seed is done to obtain good quality seed with higher germination and viability. Grading refers to classification of cleaned seeds into various quality fractions depending upon the various commercial values and usages.

Sorting refers to the separation of cleaned seeds into various quality fractions that may be defined on the basis of size, shape, density, texture and colour.

Screening

Screening is a method of separating seed into two or more fractions according to size alone. For cleaning and separation of seeds, the most widely used device is screen. When solid particles are dropped over a screen, the particles smaller than the size of screen opening pass through it whereas larger particles are retained over the screen or sieve.

Hulling This step is essential for removing pericarp, also known as cork, from the outside of the seed. Removal of the pericarp is important, because it contains chemical inhibitors that hampers seed germination.

Sizing

Seeds can vary dramatically in size even though it is within the same seed lot. Climate, environment, and grower management practices strongly influence the seed development every year. Varying genetics often result in seed that is shaped and sized differently than other genetics. All of these factors are taken into consideration during the sizing process.

The air-screen machine is the most common basic cleaner. Some seeds come from the field in good condition and require only cleaning on the air-screen machine. These machines separate crop and weed seed by differences in physical characteristics. When all undesirable material has been removed, the seeds are ready for bagging. A fungicide or insecticide treatment may be applied The seed may then be shipped directly to certified seed before bagging. growers, or held in storage until they are needed.

Complete processing depends on differences in physical properties of seed. If a difference exists and a machine is available which can distinguish between the seed at an efficient capacity, they can be separated.

Size is the most common difference between seeds. The air-screen machine uses a series of perforated sheet metal or woven wire screens to separate seed of different sizes. .

Two types of screen sizing are made:

(1) Scalping, in which good seed drop through the screen openings while larger material is carried over the screen to a separate spout

(2) Grading, where crop seed ride over screen openings while smaller particles drop through the screen.

A series of scalping and grading screens can remove all material larger or smaller than crop seed.

Seed treatments

Seed treatment can be a physical or chemical process.

Physical seed treatment : Heat treatments can be accomplished using hot water, dry heat or steam to kill seed borne pests and pathogens. Heat treatment can injury or kill the seed, especially if it is old, injured or has a low heat tolerance. Hot water treatment at 52-57^{o}C for 15 minutes can eradicate seed borne diseases.

Chemical treatment: Fungicides, bactericides, insecticides, and nematicides can be applied as gases, liquids or powder. No broad spectrum fungicides exist, so mixes may often be used.

Drying seed:

Drying makes the seeds suitable for safe storage and protects them against attack of insects, molds and other microorganisms during storage. Seeds should be dried fairly quickly after washing. Slow drying may result in mold growth or premature sprouting of the seed. Dark colored seeds are especially vulnerable to damage when sun dried. Instead, seeds should be dried in a climate-controlled environment using fan ventilation. A combination of ceiling fans and air conditioning dries seed safely and very quickly. Seed should be spread out in thin layers (no thicker than ¼" for small seeds) and then stirred several times a day until dry. Once the seeds feel dry, they should cure for another two to three weeks. Curing is the final stage in the drying process. As the seed moisture content declines it comes into equilibrium with the relative humidity. After the seeds are cured they can be placed in a container.

When seed is to be stored for long periods it should be dried to 12% or less and preferably placed in a sealed container.

Drying and tempering the grain a number of times or in stages during the drying process will maintain seed quality.

Packaging

After processing, the seed is packed. Bagging is usually the slowest and most costly operation in a seed processing plant. Bagging requires filling the bag to an exact weight, closing and labelling the bag. These operations are done either with hand or with manually operated machines, like weighing scale and bag closer.

Complete processing records need to be maintained to trace the seed from the time it is received at the plant until it is sold with full details of operations.

Seed storage

Good seed storage is an important phase of processing and is essential to successful seed marketing. Proper storage preserves seed viability, from harvest to sale, and protects the producer, the processor and the user.

Machines required for seed processing

Processing Machines

Brief descriptions of the processing machines used in a seed processing plant are given here.

Scalper

Paddy seed contains contaminants of various kinds as it comes into the processing plant especially if it has not been harvested and threshed mechanically. To get the seed into condition to flow easily through the processing operations, to improve capacity and separating precision during processing, and to prevent loss of quality, seed is usually prepared for processing by sending them through one or more special machines or processes. A scalper can be used to rough clean seed when trash content is high.

Air screen cleaner

The air screen cleaner is the basic machine in almost all seed processing plants. The air screen cleaner uses three cleaning principles viz aspiration, scalping and grading. A common air screen cleaner for processing seed uses two air blasts and two screens. The first air system removes dust and light chaff before the seed reaches the first screen. The first screen allows the good seed to drop onto the second screen. The large foreign material rides over the first screen and is discarded. The second screen is a grading screen.

Specific gravity separator

Seed of same size and general shape can often be separated because they differ in specific gravity. This difference is very useful in removing light immature seed or heavy sand and rocks to improve the purity and germination of crop seed.

Indented cylinder

Seed of the same width and thickness can sometimes be separated by taking advantages of difference of length. Indented cylinder can do very precise separation by using length difference. The indented cylinder separator is a rotating almost horizontal cylinder with a movable horizontal separating trough mounted inside it. Thousand of half round indents line the inside surface of cylinder.

Elevator

Single leg bucket elevator consisting of receiving hopper, boot, bucket, belt, boot pulley, leg, head pulley, motor, drive and discharge spout will be used for conveying seed from one machine to another machine. It will lift the seed from the ground vertically upward and discharge it from top to the different machines. This type of elevating machines requires less power and floor area.

Disk separator: The disk separator separates materials on the basis of difference in length of various constituents. The separator has pockets or indentations on its surfaces. When the machine is operated, the smaller sized materials are caught in the pockets while the larger ones are rejected. It is used specially for removing dissimilar material like wheat, rye, mustard, barley

from oats.

Spiral Separators: Spiral separator separated the grains as per their roundness. Separation of mustard, rape, soybean, wild peas or other round seeds can be performed from wheat, flax, oats etc.

Specific gravity separators: SGS makes the separation according to difference in density or specific gravity f the materials

Destoner: The destoner is a form of specific gravity separator. It separates the grain mass into two fractions as per the difference in specific gravity.

Fluidised bed cleaner/separator: makes the classification of seed due to difference in density and size. This device is suitable for cleaning lighter seeds like cabbage, raddish, lettuce, carror, onion etc.

Magnetic separator: performs separation on the basis of surface texture and stickiness properties of the seeds.

Cyclone separator: The cyclone separator is a device for collecting the end product in processing operations. It is most commonly used for collection of dust and wastes during processing of grains. It can also be used with air screen cleaners to collect light particles which could be carried out by air stream.

Conclusion

Quality seed is one of the most important input for enhancing crop production and productivity. The gap between the availability and the requirement of quality seed is quite high in the country and therefore needs proper attention. Quality control in seed processing can be effective only when it is based on a well-planned, organized processing facilities and post harvest handling operations.

Eco-Friendly Management of Diseases for Safe Storage and Export of Potato

V.S. Pundhir and Versha Joshi

Potato is an important crop in India.Potato is grown in two consecutive seasons: summer is the main potato-growing season that extends from February to June-July in hills, while in plains the main crop is grown from October to March. Factors like rainfed conditions, non-availability of quality seed, and high disease incidence, contribute to the present poor yield level.Environmental pollution and food safety due to chemical contamination have become a great concern worldwide. Farmer's traditional methods for managing the potato diseases can make a base for developing eco-friendly methods for disease management. Following are general principles that can guide us in this direction;

Plant Health Management Programme

1. Cultural Control

- **Maintain plant vigor**
- Plant and site selection
- Planting practices and spacing
- Nutrition and water management
- **Mulch**
- Soil moisture retention
- Soil temperature moderation
- Weed control
- **Alteration of date of planting**
- Delayed planting helps to manage the disease by reducing use of chemicals and producing quality tubers.
- This organic approach of planting is now widely accepted and adopted by the potato growers of this region.

2. Biological Control

- *Trichodermaviride, Trichodermaharzianum,Gliocladiumvirens, Pseudomonas fluorescens, Bacillus subtilis*and *Bacillus cereus* tested against *Phytophtorainfestans*, causal agent of late blight disease.
- This biocontrol method of disease management is now widely adopted by the farmers.
- The commercial formulations of these above antagonists are also available in the market in different trade names.

3. Chemical Control

- **Biological (biopesticide)**
- Use of living organism to control plant pathogen

- Mode of action
- Direct(parasitism, antagonism and competition)
- Indirect (induced resistance, enhance growth)
- **Biorational**
- Environment friendly
- User friendly
- **Traditional (Chemical) pesticides**
- Traditional compounds with traditional mode of action
- Some are acceptable for organic land care

4. Development of warning system

- Forecasting model was developed for late blight disease
- This model has been tested in several locations where, moderate to severe potato late blight occurs at regular intervals.
- It provides a warning of the risk of infection anytime during the season.

5. Development of host resistant cultivars to potential pathogens

Bacterial Ring Rot (*Clavibacter michiganensis subsp. Sepedonicus*)

- Bacterial ring rot is a highly infectious disease.
- Ring rot may cause wilting of the lower leaves.
- The lower stem will exude milky ooze when cut and squeezed.
- Tuber symptoms: as a cheesy cream-coloured liquid that oozes from the vascular ring when tubers are cut at the stem end and squeezed.
- Bacteria can over-winter in infected tubers in the field or in cull piles

Management Strategies

- Plant certified seed
- Thoroughly clean and disinfect equipment, tools, trucks and storages
- Dispose of any crops infected with ring rot
- Plant crops like sugar beets after potatoes
- Plough under infected potato debris prior to winter
- Allow at least ¾ years before replanting potatoes in an infested field
- Dispose of all used potato sacks or bags
- Destroy cull piles by freezing or burying
- Maintain strict sanitation

Bacterial soft rot *(Erwinia carotovora var. carotovora*)

- Bacterial soft rot is often serious disease that can affect tubers in storage, in the ground prior to harvest, or seed pieces after planting.
- Bacterial soft rot commonly invades tubers that have damaged skin due to mechanical damage or infection by other pathogens.

- Soft rot may also cause rapid and severe damage to washed and packaged fresh-market potatoes if they are not completely dried prior to packaging.
- Early season potatoes with immature skin are most susceptible

Management Strategies

- Prior to planting, condition seed tubers to approximately the same temperature as the soil,
- Clean and disinfect seed cutters, handling equipment, and trucks
- Minimize mechanical damage during harvesting, handling, and packing operations
- Avoid frost injury and properly dry frozen tubers in storage
- Use clean water or chlorinated during washing operations
- Remove potato cull piles, discarded vegetables
- Cold stored tubers are ventilated with cool air.

Common Scab (*Streptomyces scabies*)

- The pathogen causes scab-like lesions on the tuber, which vary in type: erumpent (slightly raised), russet (superficial), and sunken (pitted).
- Scab does not affect yield directly but reduces quality
- The organism prefers a pH of 5.5-8.

Management Strategies

- Plant disease-free seed into non-infested soil
- At tuber initiation, maintain high soil moisture for 4-6 weeks
- Increase time between potato crops to 3-4 years
- Plant early, harvest early

Early blight (*Alternaria solani*)

- The pathogen causes dark brown to black concentric lesions on leaves and elongated brown or black lesions on stems and petioles.
- Leaf lesions become angular if a large vein retards them.
- The fungus can survive over winter in soil or on plant debris
- Lesions produce spores that spread to healthy plants and cause infection.
- The pathogen attacks weaker tissues;

Control Strategies

- Plant disease-free seed
- Maintain good soil fertility and crop vigor
- Harvest when skin is mature to avoid bruising
- Avoid continuous potato cropping
- Apply protectant fungicides to the foliage,

Late blight (*Phytophthora infestans*)

- The pathogen can infect all parts of the plant.
- Depending upon the environmental conditions and age of the tissue, appearance of the lesions may vary.

- The disease starts as small necrotic spots,
- Lesions may start as small water soaked areas, tips / margins
- Older lesions have a necrotic centre and a pale green border.
- Stem and petiole infections destroy soft tissue
- Under humid conditions, a white fluffy growth appears at the lesion edges on the under side of infected leaves.

Management Strategies

- Use certified disease-free seed
- Destroy early infected plants in or nearby fields
- Reduce periods of leaf wetness and high humidity within crop canopy
- Follow a recommended fungicide spray program. The program should start prior to the arrival of the pathogen.
- Consult your local late blight forecast for disease risk information
- Resistant cultivars should be used in prone areas

Rhizoctonia stem canker and black scurf (*Rhizoctonia solani*)

- Symptoms include rusty brown lesions on underground stems and stolens and black sclerotia (fungal bodies) on progeny tubers.
- The leaves may turn pale green or purple and become curled and upright.
- Development of aerial tubers in leaf axils may also be observed.
- Under humid conditions, a white cottony growth develops on the lower stem.
- The disease initiates from black fungal bodies present on infected seed or from the pathogen present in the soil on plant debris.

Management Strategies

- Use only certified and black scurf-free seed
- Use a four year rotation, preferably with cereals
- Plant in warm (60-68°F or 16-20°C), well-drained soil
- Treat seed tubers
- Harvest the tubers as soon as they are mature,

Potato Viruses

- PVX : mild mottling, contact
- PVY : severe mosaic, aphids
- PVS : mild mosaic
- PVA : faint mottling
- PVM : mild mosaiic/mottle
- PV(X+Y) : rugose mosaic: aphids
- PV(X+A) : cricle

- Acuba mosaic : bright yellow spots
- PLRV: leaf roll : aphids
- PSTVd : potato spindle tubers
- Stem necrosis (tswv) : necrosis
- MF,PTR,PP,WB : phytoplasma

Potato Leafroll Virus

- PLRV is an aphid-transmitted virus.
- Primary symptoms; virus is transmitted by an infected aphid to a healthy plant.
- Ps; upright, rolled leaves, slight yellowing mainly on the young leaves.
- Leaf rolling at the base of the leaflet, eventually spread to the lower leaves.
- Plants infected early in the season may also be dwarfed.
- Secondary symptoms occur when an infected tuber produces an infected plant.
- Leaf yellowing, along with leaf rolling are often with the lower leaves.
- Leaves are dry, stiff and leathery, and make a paper-like, crisp sound.
- Plants are often stunted.

Integrated management /control strategies

- Sanitize equipment and storages.
- Plant only high-quality certified seed.
- Plant B-size seed.
- Plant resistant cultivars.
- Monitor and manage the aphid and leafhopper populations.

Low Temperature Injury

- Low temperature or freezing injury; field frost
- Frozen tissue breaks down into a soft watery mass.
- Frozen or chilled potatoes should not be used for seed
- Low temperature injury losses can be reduced or prevented by:
- Storing at temperatures above 37°F (3.0°C)
- Proper ventilation and temperature control.

Impact of Seed- borne Diseases on International Trade

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For food sufficiency India underwent introduction of new crops or high yielding varieties of indigenous planting material, particularly the seed. Of course, it helped India to sustain its food security via green revolution but at the same time there had been challenges of introduction of many seed-borne plant pathogens which later established or posed problems time to time for successful crop production.

Pathogens thus, introduced remained confined to some regions initially, but later spread all over the country. The diseases which used to be of minor importance became the major diseases in the regions where pathogen established and disseminated.

There have been the evidences that the infected or contaminated seeds at an early stage can lead to proliferation of microorganisms through out crop production leading to substantial crop losses an at times to epidemic proportion. Thus, the seed which is the key input for all crop cultivation has the potential for trans-boundary spread of plant diseases and serves as primary source of inoculum for disease epidemics.

Seeds are both the vectors and victims of diseases. Over the years, there has been a long list of seed-borne pathogens which have been intercepted during cross boundary trade by NBPGR in India through seed or planting material. With the movement of seed, which is often produced in one country, processed and packaged in a second and sold and planted in another, comes an increasing danger of the spread of seed-borne diseases.

It is estimated that 30% diseases are of seed borne nature and can be managed through disease-free seeds. The losses due to seed-borne diseases in developing countries are estimated to be 60-80% higher than in industrialized countries. Conservatively estimated, seed-borne diseases cause losses in the order of 50 million ton of food annually.

Impact of poor seed health/ seed borne pathogens

- Leads to poor seed germination to various degrees,
- give rise to pre- and post emergence seedling mortality and progressive disease development in the field and thereby reduces the yield and quality of the crop
- contaminate previously disease-free areas,
- spread of the diseases across national or international boundaries,
- reduce shelf life of the seed, and
- affects food safety /mycotoxins /nutritional value.

Significance of Seed-borne pathogens

In worst-case scenario, seed-borne diseases can be disastrous and even life threatening. Consumption of molded grains of wheat, millet, and barley with *Fusarium* killed thousands of human beings in the USSR in 1913 after World War II due to toxin production by the fungus.

Effect of Seed borne diseases in crop production

The major component of losses due to seed borne pathogens are :

1. Quality loss,
2. cost of planting restriction,
3. loss of seed export ,
4. additional cost of transportation ,and
5. yield losses.

Few examples which exemplify the significance of seed borne pathogens and their effect on seed production are: Blast of rice (*Pyricularia oryzae*) which had been so much so devastating and was held responsible for famine in Japan in 1930. Yield losses had gone upto 100% due to loose smut in wheat (*Ustilago segatum* var. *tritici*) in Georgia.

Brown spot of rice (*Drechslera oryzae*) ,a devastating disease, was held partly responsible for Bengal famine in 1942-43 in India. The fungus is major components of the dirty panicle syndrome of rice. Another menace to wheat is glume blotch (*Septoria nodurum*) , known to be present serious in many European countries , USA and India causing substantial losses in wheat productivity.Losses due to Karnal bunt of wheat in North Western Mexico have been estimated to an average of $7.02 millions/year. An unexpected spread of ergot (*Claviceps microcephala*) in bajra from multiplication centres in Maharashtra to many region of the states(Punjab, Rajasthan and Uttar Pradesh) in India had caused damages to an extent that many crops had to be burnt in order to prevent further ravage and spread(1968). The seed borne nature of blight (*Ascochyta rabiei*) has been well known in Punjab and North West UP (Neergaard 1968). Menace to chickpea by Ascochyta blight (*Ascochyta rabiei*) has happened in the year 1982-1984 in India and Pakistan. The diseases occurred in serious proportions and caused substantial yield losses. In severely infected fields no seed setting could be observed.

Sunflower downy mildew (*Plasmopara helianthi*) was unknown in India until 1984. In 1985, it has been reported to occur in a serious form in Maharashtra. The causal fungus *Plasmopara helianthi* is considered to be of North American in origin. It has been distributed rapidly by seed trade. Observations indicated the large scale reduction in yield due to attack of this disease. In Canada the losses attributed due to Helminthosporium Leaf Blight (HLB). *Bipolaris sorokiniana*" have been equivalent to $42millions in 1971.

Resurgence of diseases

Spot blotch or Helminthosporium Leaf Blight (HLB): *Bipolaris sorokiniana"* resurged in serious proportion during 2008-2009 in different districts of Sindh and Punjab. Farmers in Sindh were celebrating the spring festival in March 2009 anticipating a rich wheat harvest from their fields due to ideal environmental conditions. But after the harvest, the situation for many changed and their happiness turned into gloom when they found that the yield was contrary to their expectations. The yield reduced from 6.0 tons/ha to a mere yield of 1.6 to 2.2 tons/ha from their potential lands.

Several bacterial diseases are well established in seed stocks. Few examples are: bacterial blight in rice (*Xanthomonas oryzae*) ;common bacterial blight of bean (*X.phaseoli*); black rot of crucifers (*X.campestris pv. campestris*); and Black arm in cotton (*X.malvacearum*) These diseases caused major menace to the respective crop production.

Bacterial blight of paddy was 1st observed in Mahrashtra (formerly Bombay) State in 1951, when it was reported in Kolaba District but it was not until 1963 that an outbreak of disease occurred accounting for total crop failure as happened in Punjab, Haryana and Western Uttar Pradesh States of India in 1979 and 1980. In India, the disease has accounted for more than 20% rice crop loss, periodically. Most Seed borne viruses are asymptomatic and transmit efficiently through infected seed and further disseminated by a number of vectors. The losses are attributed to the environmental conditions and the prevalence of the vector population in that area. For example, one infected plant will produce 100% infected seed (soybean mosaic virus) such seed will be viable and germinate well, but the resulting plants will be infected and yields will be significantly reduced. All these examples exemplify the significance of seed borne pathogens and their effect on seed production.

New Challenges

With the new dimensions in Indian agriculture, which is not only confined to the varietal developments by conventional breeding for crop improvement in yield and quality traits but for value addition and for food biosecurity, new tools are being used for crop improvement, (transgenics, or BT crops) by way of biotechnology. This may change the scenario of the pathogens and plant diseases in agriculture. Thus, a threat form exotic destructive pests is foremost importance in the era of liberalized import under WTO. However, the changing conditions the indigenous pests already existing but having the lower damage level in India are changing their habit and gaining importance over the years.

Resurgence of seed-borne diseases: cropping system

With the change in cropping system there is resurgence of diseases. Examples are necrosis in sunflower and ground nut that can not be neglected for crop production and food security. Apart from the threat posed by resurgence, a large number of diseases are endemic and continue to cause losses in given area ,example is Karnal Bunt of Wheat.

Resurgence of seed-borne diseases: Chemical pesticides

With the excessive use of chemical pesticides, number of resistant strains of pests have evolved which are the constant threat and need improved measures for disease management

Seed-borne diseases and Seed health: perspective

Role of seed sector in agriculture

As a consequence of increased product liability and competitive pressure with in the seed industry, seed health has also become an important quality trait in market place. In industrialized countries, the formal seed sector provides the vast majority of seed to farmers where the seed health issues are well taken care of. Inspite of large investments in formal seed systems in

developing countries over the past 30 years, about 90–95%, of smallholder farmers' seed demands are still met by informal sources at farm and community level.

Seed health in relation to crop production

The microorganisms associated with seeds can be overtly pathogenic, asymptomatic or latent in seeds, and therefore if unsupported by a definite seed health test may cause a typical disease syndrome or otherwise interfere to reduce final yield and quality of the produce.

Risk associated with import

Seed health testing helps in checking the transboundary introduction of alien species of plant pathogens which once introduced may be devastating or are difficult to get rid off .

Seed health testing helps in anticipating the effective disease management choices and thus helps in reducing the cost of production which otherwise would have been expensive. For healthy seed production seed health certification program must go hand in hand with proper seed processing.

More-over seed health testing is one of the important tools for monitoring seed quality and advisement for seed treatment.

Seed Health Testing

The demand and pressure for seed health testing is however increasing to deliver healthy seed to farmers and seed producers. SPS (Sanitary and Phytosanitary) issues in WTO are pressurizing the developing countries to give special attention to seed health testing and to respect International Phytosanitary Regulations (IPR) issues.

Seed health management

Seed health management needs to be focused on:

- Estimation of losses attributed to seed-borne inoculum
- Predictive relationships between seed-borne inoculum and disease incidence
- Developing reliable, effective, cheap and rapid detection methods
- An understanding of pathogen tolerance in a seed lot before a technique is an acceptable clinical seed health test.
- Establishment of seed health certification schemes
- Decisive proper seed processing and seed treatment

Advances in Seed Health Testing

The first *International Rules for Seed health Testing* was published by ISTA in 1928. This document contained a special section on *Sanitary Condition* in which special attention was recommended for *Claviceps purpurea, Fusarium, Tilletia,* and *Ustilago hordei* on cereals; *Ascochyta pisi* on peas, *Colletotrichum lindemuthanium* on beans; and *Botrytis, Colletotrichum linicola,* and *Aureobasidum lini* on flax. The demand for better seed quality, greater sensitivity and shorter turnaround times for seed testing is forcing seed health testing laboratories to incorporate new technologies which will provide the user with a significant level of reliability, sensitivity, and reproducibility of the test . In last 35 years, several seed health testing procedures, published by International Seed testing Association (ISTA) are now obsolete and need to be revised or

revalidated by newer technology due to fast pace of technological development.

Seed Testing Methodologies

- Many conventional seed health testing methods have been developed such as:
- agar plating
- blotter test
- seedling bioassay
- microscopic observation
- Direct isolation of pathogens
- growing on test
- However, they are multi-stage, and are often slow, cumbersome time consuming, labour-intensive and subjective.

Seed Health Test Organization

During the past decade, several organizations have begun to address this situation by promoting research, development, implementation, and standardization of seed health testing methods.

These organizations include:

- The International Seed Testing Association (ISTA),
- International Seed Federation (ISF),
- International Seed Health Initiative (ISHI), and
- The National Seed Health System (NSHS) In the United States

Earliest amongst these was ISTA, which formed a Seed Health Committee (SHC) as early as 1928. The committee was alternatively referred to as the SHC or Plant Disease Committee (PDC) until 2002, when the PDC was finally designated to SHC. In first several decades SHC of ISTA focused on cataloguing seed-borne microorganisms rather than the practical aspects of detecting pathogens in a phytosanitary context. The current Seed Health Committee's objective is **to** *"develop and publish validated procedures for seed health testing, and to promote uniform application of these procedures for evaluation of seeds moving in international trade"*

The International Seed Health Initiative-Vegetables (ISHI-Veg) started in 1993 as an initiative of the vegetable seed industry. International Seed trade Federation (ISF) started two more ISHI's (ISHI for herbage crops in 1997 and ISHI for field crops in 1999). These ISHI's put more emphasis on quarantine pathogens and their impact on the international seed trade. In 2002 all the seed health testing methods were validated and accepted according to the ISTA rules and published as "Hand book of method validation" 2002.In 2005 ISTA–SHC emphasized **the** validity of a test protocol and characterization of new seed borne pathogens .

Non destructive seed health test

Indexing the seed for health through non destructive seed health test is carried out by methods like:

- Ultra sound

- Optical and infrared analyses, and Biopsis

Advances in Indexing Seed for Pathogen

Several advances in seed health testing have been made such as:

- Liquid plating assay (seed-borne bacteria)
- Enzyme-Linked Immunosorbent Assay (seed-borne viruses)
- Serology and
- Polymerase Chain Reaction (PCR)/ molecular biology based techniques

Serological Methods

These methods are generally simple to perform, rapid and accurate when used, generally to detect a number of bacterial and viral pathogens even if present in low level. These methods are being applied for many seed borne pathogens successfully, for example

Indexing seed for lettuce mosaic virus was started as grow-out assay on several thousand seedlings (30,000) Later the test was changed to indicator host plant *Chenopodium quinoa test .* Further ,since 1983, ELISA (enzyme-linked immunosorbent assay), has been used which not only proved to be more efficient but very sensitive in detecting low levels of infections that could potentially threaten lettuce production.The lack of sensitivity and ambiguity in results and inability to detect all strains of the pathogen sometimes limits their use.

Indirect Immuno-fluorescence Colony Staining Method

Used for detection of seed-borne bacterial pathogens. The test is especially suitable for seed companies, and quarantine stations which have no facilities for conjugation of primary antiserum. The assay is easy to perform and quick to be assessed. Choosing the right secondary conjugate is however, necessary to get best results in the assay.

Nucleic acid based detection methods

Highly sensitive BIO-PCR methods have been developed for several bacterial pathogens from seeds, including *Pseudomonas syringae pv. Phaseolicola, Acidovorax avenae ssp. Avenae, Xanthomonas oryzae pv. oryzae and X. campestris pv.campestris* .

A DNA-based polymerase chain reaction (PCR) has been developed as an alternative or supportive method to a costly and time consuming grow-out test (10,000 seedlings) for detecting (*Acidovorax avenae sub sp. citrulli*), the cause of watermelon fruit blotch .

Molecular Methods

Certain laboratories are testing the D-Genos ready-to-use kits to detect certain seed borne bacterial pathogens (*Pseudomonas savastanoi* pv. *phaseolicola* and *Xanthomonas axonopodis* pv. *phaseoli* on bean seeds) .The data obtained are conclusive enough to allow the use of D-Genos kits for routine testing as an alternative to standard procedures.

Populations of two fungal pathogens of rice - Bipolaris oryzae (Cochliobolus miyabeanus),(brown spot) and Saracladium oryzae, (sheath rot) - were used as model pathosystems.Methods were developed to characterise these organisms using polymerase chain reaction (PCR) with both random amplified polymorphic DNA (RAPD) and simple-sequence repeat SSR oligonucleotides as

primers.

Ustilago nuda infection of barley seed can be readily detected by PCR using primers Uh 1 and Uh 4 when the seed has a high level of infection. However, a better DNA extraction method is needed in order to detect the required limit of 0.2%. The fungal pathogens which are difficult to be distinguished on the basis of colony characters or on spore morphological characters owing to their similarity, PCR based assays are the right answer in such cases .

Constraints in seed health testing on routine basis

To date there has been no systematic attempt to evaluate the large number of test procedures for their appropriateness, whether in terms of cost, ease of use, but even more importantly their scientific validity.

Challenges for seed health testing in Seed Industry

- Require greater emphasis by plant protection authorities on seed health testing
- Reliability of tests questioned
- Harmonisation of tests
- Use of protocols suitable to test seed.

Selection and Application of *Trichoderma* for Safe and Quality Management of Plant Diseases under Organic Farming

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The selection and application of potential *Trichoderma* isolate is the present days need as environmental pollution (air, water & soil which affect food chain) and development of pathogen resistance is increasing day by day due to the excessive use of pesticides, The consumer also prefer pesticide free and organic produce under sustainable crop production. Still we have no alternative economic methods against soil borne plant pathogens. The growth promoting effects have also been observed in many crops by the use of *Trichoderma*. In spite of many advantages the application of *Trichoderma* has been found limited success at farmer's field. It may be due to lack of proper screening methods to select potential isolates which have better competitive ability, to survive under adverse climatic conditions and apply with suitable formulation. Therefore, large number of strains need to be screened in order:

1. To select *Trichoderma* isolates intended for use under abiotic stress like cold tolerant (360 *Trichoderma* strains , Antal *et al.,*2000) , high temperature tolerant, low water potential tolerant, high pH tolerant etc.;
2. To collect information of compatibility of *Trichoderma* with commonly used biocides ,fertilizers and mineral nutrients for its use under IPM programme;
3. To select *Trichoderma* isolates which compete antagonistic bacteria present in the soil
4. To develop suitable cost effective formulations which may easy to applicate, retain its longevity with high spore/mycelium with antibiotic and secondary metabolite substances for better competetitive survivability in spermosphere ,rhizosphere against plant pathogens and antagonistic bacteria .

Methods of Isolation and Screening for the selection of Potential *Trichoderma* isolates for safer use against plant diseases

I. Isolation & Purification

II. *In-vitro* Evaluation

A. Dual culture

1. Mycoparasitism
2. Antibiosis

a. Non volatile compounds
b. Volatile compounds
c. Enzymes

B.Compatibility with fungicides, insecticides , herbicides and botanicals

C.Tolerant to abiotic stress (Drought and Salt)

III. *In-vivo* (Glasshouse studies)

A. Rhizosphere , Spermosphere competent
B. Competent to Seed , soil and foliar pathogens
C. Plant growth promoter
D. Systemic induced resistance
E. Tolerant to abiotic stress (Drought and Salt)

IV. Formulation

A. Mass multiplication
B. Quality parameters
   i. Spore concentration
   ii. Shelf life
   iii. Nutrients for initial establishment
   iv. Having the properties of good adjuvant

V. Field Testing

Delivery system against seed, soil and foliar diseases

A. Seed treatment
   i. Seed coating
   ii. Seed Bio-priming
B. Soil Application
   i. Cow dung
   ii. FYM
   iii. Vermi-compost
C. Drenching
D. Seedling dip treatment
E. Foliar spray

VI. Maintenance of culture to maintain its potentiality

Isolation of *Trichoderma*

Collection of soil: The soil should be collected from the

i. Field where the pathogen is known to be present but disease occurrence is low
ii. Areas where a pathogen was introduced but not established
iii. Monoculture of crops where diseased intensity has decreased
iv. Soil from rhizosphere/ rhizoplane of the healthy plant from the infested areas

From Rhizosphere

i. Dig out plants with roots, gently shake off the excess soil and discard.
ii. Collect soil adhering closely to the root
iii. Place 10g soil in a flask and add 90 ml sterile water
iv. Make serial dilutions (10^{-3}-10^{-4})

v. Transfer 1 ml of solution in plates containing TSM

vi. Incubate at 26± 1^0C

From Rhizoplane

i. Root pieces in 100 ml sterile water

ii. Serial washing 10-20 times

iii. Make serial dilutions (10^{-3}-10^{-4})

iv. Transfer 1 ml of solution in plates containing TSM

v. Incubate at 26± 1^0C

A proper dilution allows 50-150 colonies per culture plate

Modified *Trichoderma* specific medium (Mukherjee,1991)

$MgSo_4.7H_2o$	0.20 g	Captan	0.20 g
K_2HPO_4	0.90 g	Apron 35 SD	0.015 g
KCl	0.15g	PCNB	0.20 g
NH_4NO_3	3.00 g	Rose Bengal	0.15 g
Glucose	3.00 g	Agar-agar	20.0g
Chloromphenicol	0.25 g	Water	To make 1 lit.

***In-vitro* evaluation and selection**

Dual culture Method: This method is used for testing mycoparasitic activity of antagonist. Pour 15-20ml sterile PDA in sterile plates amended with Chloromphenicol (100 mg/lit.) or streptomycin (100mg/lit). Place the bits (5mm) of the test pathogen as well as antagonist on the PDA plates opposite to each other from 1.0 cm from the periphery of plates (if both are fast growing) or place it 2-3cm apart (if both are slow growing). Incubate the plates at 25±1^0C for desired duration. Observe the plates regularly.

(A). Mycoparasitism:

In mycoparasitism the pathogen stops growing upon contact with the antagonist and its mycelium begin to lyse backwards and the antagonist continue to grow over the test fungal pathogen.

Observations

- First observation should be taken just after contact and measure the growth of the pathogen in dual culture**.**

After contact, observations should be taken regularly at 3 day interval until the antagonist completely parasitizes the test pathogen or antagonist stops growing over the test pathogen. Calculate the percent inhibition (parasitized growth) of the test pathogen by comparing the growth of the pathogen (after parasitization) with its initial growth (just after contact). To see the hyphal interaction small bits of mycelium can be taken from interaction zone and observe under microscope.

Mycoparasitism of Sclerotial plant pathogens

Collect freshly non-dried sclerotia , surface disinfested and wash in sterile distilled water. Immerse these sclerotia in an aqueous spore or mycelial suspension of the antagonist for 1-5 min. Place these sclerotia in culture plates containing sterile moist sand. Incubate it for 1-4 week at 25-28^{0}C. After desired period of time observe colonization of antagonist on decayed sclerotia

B). Antibiosis:

The antagonists that has antibiosis effect (formation of zone of inhibition) in dual culture must be further tested using cellophane membrane and cell free culture filtrates

Non Volatile compounds:

1. Cellophane membrane method

Place sterilized disk (90mm) of a cellophane membrane on culture medium. An agar disk of antagonistic fungus is placed at the centre of the cellophane membrane. 3-4 days after incubation, remove the cellophane membrane along with the growth of antagonist. An agar disk from culture of actively growing test pathogen is transfer to the position previously occupied by the antagonist. Test pathogen grown on PDA plates serves as check. The radial growth of the test pathogen is recorded 3-4 days after incubation and compare with check. The reduction in radial growth of the test pathogen shows production of non-volatile compounds by the antagonist.

2. Cell free culture filtrate

The antagonist is grown on potato broth medium either in stationary or in shake culture. After sufficient mycelium growth the mycelium and other cells are removed by filtration through filter paper and then sterilized by passing through G_1,G_3 and G_5 sintered glass filter. The cell free sterile culture filtrate is tested for efficacy of antagonist against the fungal pathogens by following ways.

a. Assay in solid medium
    i. Food Poison technique
    ii. Filter paper disc method
    iii. Agar well method
b. Assay in liquid medium
c. Spore germination test

a. Assay in solid medium

i. Food Poison technique

Mix sterile cell free culture filtrate in sterilized PDA flasks (various concentrations) and pour in Petri dishes. Inoculate the test pathogen at the centre of the PDA plates. Pathogen on PDA plates without culture filtrate serves as control. Incubate at 25$\pm$1^{0}C for desired duration. Per cent inhibition was calculated by measuring the radial growth of the test fungus in amended medium and compare with check.

ii. Filter paper disc method

Pour 15ml of a PDA in sterile Petri plates. After solidification uniformly spread 4ml of 1.5%

water agar, seeded with 10^4 spores/ml of the test pathogen. 4-6 filter paper dics (1-2 cm dia, autoclaved and dried) soaked in culture filtrate and dried, are place on the seeded agar medium from 1-1.5cm periphery of the plates. After incubation measure the zones of inhibition around the filter paper .

iii. Agar-well Method

Prepare PDA plates as above. Remove Agar plugs at a distance of 1-2 cm from the periphery of the PDA plate with the help of cork borer of 1-2 cm dia. Fill the wells with a known concentration and standard quantity of the cell free culture filtrate. After incubation, measure the zones of inhibition around the wells.

b. Assay in liquid medium

Add sterile culture filtrate at desired concentration in a known volume of potato broth and mix well. The flasks containing medium is inoculated with a 5 mm discs (2 no.) of the test pathogen. Incubate until sufficient growth has occurred in check (medium without culture filtrate) flask. Measure fresh and dry weight of the test pathogen growth and calculate per cent inhibition

c. Spore germination test

Place 0.2-0.5ml of the desired concentration of the cell free culture filtrate in the wells of a cavity slide and dry at room temp. The same amount (0.2-0.5ml) of spore suspension of the test pathogen ($5X10^3$ spores/ml) is added over the dried culture filtrate and mix well with help of a glass rod. Incubate it in a humid chamber at 25-28^{0}C. Spore germination and characteristics of the germ tube is recorded at 12 hr interval and compare with check (cavity slides without culture filtrate) and calculate per cent inhibition.

Volatile compounds:

Grow antagonist on PDA plates. 3-4 days after incubation, inoculate the test pathogen in separate PDA plates. Place inoculated test pathogen (upper) on the 3-4 days old antagonistic plates (lower) by removing lids of both the plates. Make pair by binding both the plates opposite to each other with parafilm. Incubate the paired plates until full growth has occurred in check plates (inoculated with test pathogen alone). Calculate the per cent growth inhibition by measuring the growth of the test pathogen and comparing it with check plates. The reduction in radial growth of the test pathogen shows production of volatile compounds.

C. Compatibility of fungal antagonist with commonly used chemicals:

'Food Poison Technique' is used to test the compatibility of fungal antagonist fungicides, insecticides, herbicides and other chemicals to be commonly used for plant health.

II. Evaluation and selection of promising *Trichoderma* isolates in glasshouse

1. Disease Management

A. Seed treatment

B. Seedling dip treatment

C. Soil application

D. Soil drenching

Observations

i. Disease incidence / Disease severity

ii. Population dynamics (CFU /g soil at 7 days interval)

2. Systemic induced resistance

A. Seed treatment

B. Seedling dip treatment

C. pre-spraying

Observations:

a. Peroxidase,

b. Phenyl alanine ammmonia lyase

c. Polyphenol oxidase

d. H_2O_2 content

e. Phenol content

f. Superoxide dismutase

g. Lypoxygenase

h. Chlorophyll content

i. Membrane stability index

3. Plant growth promoter

Observations:

a. Biomass of plant

b. Root length & weight

c. Shoot length & weigh

III. Qualitative parameters for formulation

a. Spore concentration

b. Shelf life (Viability)

c. Food for initial establishment

IV. Field Testing

V. Maintenance of culture

Selection of promising *Trichoderma* isolates for commercialization

i. Select broad spectrum isolate.

ii. Evaluate performance under the range of environmental conditions.

iii. Evaluate formulations.

iv. Evaluate application methods.

The application of mycoparasitic *Trichoderma* strains with improved tolerance of unfavorable environmental conditions (cold-tolerance, osmotolerance, bacterium-tolerance, pesticide- or metal-resistance) could increase the efficacy of fungal bioagents against fungal plant pathogens under a wider range of environmental conditions for safe and quality management of plant diseases under organic farming.

The Threat of Plant Diseases to Food Security

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Global food situation

The world's population is anticipated to increase from 5.7 billion in 1995 to 7.7 billion in 2020 (FAO 1996). Of this, 80% live in developing countries, where the population increases by 1.9% per year. Most poor people live in areas where the land is marginal and ecosystems are fragile. Global food production is 5 billion tons per annum and at least 10% of global food production is lost to plant diseases (Christou and Twyman 2004; FAO, 2000; James, 1998). Plant pathologists cannot ignore these figures for food shortage and the damage to food production caused by plant pathogens.

Food security

According to the United Nations Food and Agriculture Organization **(FAO)**, "food security exists when all people, at all times, have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life". Global food security is influenced by a number of factors, the key ones being the rates of population and economic growth, food productivity per unit area and food distribution. While population growth is increasing all the time, the area under cultivation is fairly constant. This brings the food security issue into focusing on increasing crop yields per unit area.

Reason of world food problems

Crop failures indirectly and directly relate to plant diseases. Data suggest that population increases are not causing food crises; rather that natural disasters, plant diseases, and human influences are the real culprits. Hunger and malnutrition are a result of poverty and lack of accessibility to quality food. Famine and malnutrition are often the result of a combination of factors including adverse weather, poor agricultural production (pests, pathogens, lack of inputs/water), civil strife, population displacement, inadequate food distribution, and economic sanctions.

To feed the ever growing population and ensuring food security, a focus was drawn on yield and modernizing farming with the Green Revolution model of agriculture. Although it successfully ensured the food security, but there are a host of environmental and health consequences, directly linked with the model of agriculture that the Green Revolution espoused, and which have implications for food consumption and nutrition.

From the pathologist's point of view, the most critical effect of the Green Revolution is the increased use of pesticides and chemical fertilizers. The Green Revolution changed the 10,000-year evolutionary history of crops by changing the fundamental nature of seeds. As a result of these components of the Green Revolution a lot of negative effects occurred including land degradation and genetic erosion, which resulted in explosive growth of pests and diseases in the crops.

Although plant breeders have bred new varieties for increased pest resistance, they have also tested the crops under pesticide use, and the seeds have typically been promoted with the use of pesticides (Lipton and Longhurst 1989). Furthermore, most high-yielding varieties have been grown under irrigation, and with the addition of fertilizer and monocropping, creates an ideal environment for pest and weed growth. Pesticide use rose to over half a billion tons in the developing world by the 1980s, accounting for 1/5 of global production, with a much higher rate of insecticides, which are more toxic to humans and other organisms compared to herbicides (Conway 1997). In addition to the obvious human health implications, excessive pesticide use can increase pest outbreaks by increasing resistance in pest populations while eliminating natural pest predators (Conway 1997). All of these effects have implications for food consumption and nutrition, through complex and inter-related pathways.

Why do diseases and pests of crops matter?

The impact of pests, diseases and weeds on food supply is as high that they reduce production by at least one-third, and that diseases alone reduce production by more than 10% despite the use of pesticides worth $32 billion. If the post-harvest losses are also included the situation becomes even more alarming. History illustrates that plant diseases can have a significant effect on human society. Throughout history, food crises caused by plant disease epidemics have resulted in starvation and displacement of millions of people. Entry and establishment, emergence and outbreaks of plant diseases have historically resulted in major food problems either directly through yield reductions of food crops or indirectly through yield reduction of cash crops.

One of the first examples of plant pathogens influencing religion and cultural practices was the result of rust diseases of cereals around 700 B.C. The Great Hunger of 1044 was caused by poor weather, animal diseases, and several unknown plant diseases (possibly ergot and root rots). This led to widespread famine and disease throughout medieval Europe. The Irish Potato Famine of the 1840's caused by the blight fungus *Phytophthora infestans*, clearly illustrates the far-reaching effects plant pathogens can have on religion, politics, art, economics, and culture. By the end of the famine, the population of Ireland dropped from 8 million to 5 million people. Approximately 1.5 million of those victims died as a result of either famine or disease, and the rest were forced to immigrate to North America. The Bengal Famine of 1943 caused by a devastating disease of rice called brown spot caused by *Bipolaris oryzae* led to the death of an estimated 4 million people in India. An unexpected and devastating epidemic of southern corn leaf blight (caused by *Cochliobolus heterostrophus*) occurred on the maize crop in the United States in 1970, resulting in an estimated loss of 1 billion bushels of the crop with a value of $1 billion (Tatum 1971). Maize was the principal component of human food, livestock feed, and it was a major export commodity. The impact was seen as a potential agricultural crisis.

Crop losses due to plant diseases

Our knowledge of global crop losses due to pests is very limited. Pest infestations often

coincide with climatic changes such as irregular rainfall, increased humidity, or drought, which in themselves may lower crop output. Pest outbreaks may have a devastating impact in a given year, but cause only marginal losses in other years **(Yudelman, Ratta, and Nygaard 1998).** A comprehensive study of pest-induced crop losses was published in 1994 **(Orke et al. 1994)**. It covers eight crops that together occupy half the world's cropland, with harvests worth $300 billion in 1988–90. The study found that pests accounted for pre-harvest losses of 42 percent of the potential value of output over 1988–90, with 15 percent attributable to insects and 13 percent each to weeds and pathogens. An additional 10 percent of the potential value was lost post-harvest.

The breakdown of plant disease losses in monetary terms and percent by region and crop is shown in Tables 1 and 2. Losses due to plant diseases vary from 9.7 percent of the potential production (actual production plus total estimated losses) in North America to 15.7 percent in Africa. The largest losses are for rice and wheat, key developing country food crops.

Table 1: Estimated crop losses due to plant diseases by region, 1988–90

Region	US$ in billion	Percent of potential production
Asia	43.8	14.2
Former Soviet Union	8.2	15.2
North America	7.1	9.7
Latin America	7.1	13.5
Europe	5.8	9.8
Africa	4.1	15.7
Source: **Oerke et al. (1994).**		

Table 2: Estimated crop losses due to plant diseases by crop, 1988–90

Region	US$ in billion	Percent of potential production
Rice	33.0	15.1
Wheat	14.0	13.6
Potatoes	9.8	16.4
Maize	7.8	10.9
Source: **Oerke et al. (1994).**		

Chemical pesticide for food security:

In order to maintain the productivity of high yielding varieties, all the inputs including pesticides are essential. If pesticides are not used at the proper time of need, the investment made in seed, fertilizer and irrigation will be wasted. Besides efforts to raise productivity and realize the yield potential of a variety, we have to check losses caused by pests and pathogens. Example from India shows that as per the estimates by the central Pollution Control board, the food grain loss is due to weeds (28%), diseases (25%), insects (23%), during storage (10%), rats (8%) and by others about (6%). Various estimates are available as to the losses caused by different pests. If

we take an average loss of 20%, based on the present gross value of agriculture produce, the loss comes to Rs. 2.5lakh crore per annum. The country can not afford such a colossal loss year after year, especially when we are striving hard to achieve assured food grains production and food security globally. **(Walia and Dikshit 2009)**

Table 3:Estimated yield gaps of various countries and world average. (Walia and Dikshit 2009)

Yield gaps						
Crops	USA	China	Pakistan	Japan	India	World average
Paddy	7748	6074	3055	5850	2077	3837
Wheat	2974	3907	2381	-	2617	2665
Maize	8924	4854	1475	-	2114	4472

Pesticide production and consumption:

India has 170 million ha of arable land with average pesticide consumption ranging from 0.38 to 0.5kg/ha. In terms of total consumption, crop protection chemicals currently cover about 30% of the total cultivated area in India of which insecticides account for 60% followed by fungicides (20%), herbicides (15%) and others 5-1%.Farmers in developed countries use more herbicides (44%) than insecticides (30%) and fungicides (21 %),whereas Indian farmers apply more insecticides and fungicides than the herbicides. In terms of total pesticides consumption, India is placed 10th in the world. Comparatively lower consumption of pesticides in India has been attributed to fragmented land holdings, limited irrigation, and low awareness among the farmers about the benefits of pesticides use. Insecticides account for approximately 60% of the total pesticides consumption. Approximately 3% of the pesticides used in the world are utilized in India. Cotton crop alone consumes 44.5% pesticides followed by rice (22.8%). **(Walia and Dikshit 2009)**

Table 4: Year wise capacity, production, import, export and consumption of agrochemicals in India

Agrochemicals	**2001**	**2002-3**	**2003-4**	**2004-5**	**2006-7**	**2007-8**
	(In Thousand tones)					
Capacity	138	139	134	146	-	1.9
Production	82	72	84	94	85	4.7
Import	1.0	0.6	2.0	2.0	3.0	26
Export	13	17	20	22	33	19
Consumption	70	55.6	66	74	55	2.0
Source:	*Annual Report 2005-06, Department of Chemicals and Petrochemicals. Govt. of India.*					

Table 5—Country wise pesticide consumption pattern of the world (Walia and Dikshit 2009)

Country	**Pesticide consumption a.i. (kg/ha)**	**Country**	**Pesticide consumption a.i. (kg/ha)**
Taiwan	17.0	Mexico	1.37
Hungary	12.57	Thailand,	1.36
Republic of Korea	6.55	Indonesia	0.57
Italy	4.33	India	0.50
Japan	10.80	Turkey	0.298
China	2.25	Argentina	0.295
Europe	1.90	Africa	0.130
USA	1.50	World Average	0.500

Pesticides play a major role in attaining food security through modern agriculture. They have contributed to dramatic increase in crop yields and enabled the growers to produce some crops profitably in otherwise unsuitable locations, extend growing seasons maintain product quality and extend shelf life. Pesticides have eased the hardship of manual weeding. Use of pesticides has enabled farmers to grow more per unit area, with less tillage, reducing pressures on forests and other uncultivated lands and conserving natural resources.

The paradox of chemical pesticides

Many crops do benefit from routine or managed application of pesticides and this remains one of the principal control methods available for pathogens, especially fungi and nematodes, and their vectors, especially insects and nematodes (Hewitt HG. 1998). In developing countries the use of pesticides is critically important for seed health. Pesticide use is particularly appropriate in systems of integrated pest management (Maredia et al 2003), which aims to create a sustainable balance of complementary approaches to disease control, avoiding excessive use of pesticides whose side-effects may be unwanted. Chemical pesticides have reduced crop losses in many situations, but even with a very substantial increase in pesticide use, the overall proportion of crop losses and the absolute value of these losses from pests appear to have increased over time. Despite this perverse relationship, an increase in pesticide use still appears to be profitable. Increased monoculture, reduced crop diversity and rotation, reduced tillage, and use of herbicides have all boosted yields, but have increased vulnerability to pests as well. Pests tend to develop resistance to pesticides, requiring higher use to sustain production (Oerke et al. 1994). At present, pesticides are used only on about one-third of the cropped areas of the world. More than 50 percent of the global consumption of pesticides takes place in North America and Western Europe, regions that contain about 25 per cent of the global crop land; on the other hand, around 20 per cent of this global consumption occurs in developing countries on 55 per cent of the world's agricultural land. The actual and projected patterns of distribution and consumption of pesticides have changed marginally over the past 15 years. *(Source: Fredonia Group; cited in Agrow 1995)*

The factors that worked to increase pesticide use included the following:

1. A chemical bias existed in promoting technological change at the farm level.
2. In order to encourage pesticide use, many governments subsidized pesticide prices directly and indirectly. This practice of subsidizing pesticide use is still wide spread.
3. Private agrochemical companies do aggressive and effective sales campaigns of the efficacy of their product and demonstrate the direct value to farmers by use of pesticides.
4. Extension services promote the use of pesticides because chemicals are relatively easy to apply and pro duce immediate results.

Safe use of Pesticides:

Pesticides are an important component of IPM in order to bring down the pest population below the economic injury level. The need based pesticide use will continue to play a vital role to sustain increased productivity levels, necessary to meet the demands from ever growing world

population. Decreased use of pesticides would be enormously damaging to food production, food quality and environmental protection. According to Dr. Norman E. Borlaug, a complete ban on pesticide use in agriculture might result in 50% reduction in crop production and 4-5 fold increase in food prices. However, indiscriminate use of pesticides may lead to undesired environmental and health hazards. The adverse effects of pesticides have been mainly attributed to:

1. Misuse, overuse and increased use of sub standard products.
2. Non observance of prescribed waiting period.
3. Wrong advice and supply of wrong pesticides to the farmers by the dealers.
4. Continuance of old generation pesticides in agriculture.
5. Wrong disposal of left over pesticide containers

Role of Breeding for disease resistance:

Breeders have been able to breed many crop varieties that exhibit resistance to fungal diseases affecting the parts of the plants outside of the soil, as well as to nematodes and viruses. However, only about 5 to10 percent of the crops grown today have significant built- in insect resistance and only about one percent have significant weed resistance. However, with out adequate resources, plant breeding will be restricted and unable to continue to play an important role in improving and sustaining pest resistance in the major food crops grown in the tropics.

Role of Biotechnological tools:

Modern agricultural biotechnology is one of the most promising developments in modern science. Used in collaboration with traditional or conventional breeding methods, it can raise crop productivity, increase resistance to pests and diseases, develop tolerance to adverse weather conditions, improve the nutritional value of some foods, and enhance the durability of products during harvesting or shipping. This can be done with little or no risk to human health and the environment. The use of bio technology for the improved management of pests encompasses:

1. Disease- free planting material produced through tissue culture and micro propagation;
2. Diagnostic techniques developed for improved identification and monitoring of pest populations and pesticide residues;
3. Biopesticides or microbial pesticides that use microbes like *Bacillus thuringiensis* (Bt) and baculo viruses; and
4. Transgenic genetically engineered plants with increased virus, pest, and disease resistance.

Of late, however, considerable resistance to agricultural biotechnology has arisen on the grounds that it poses significant new ecological risks and that it has unacceptable social and economic consequences.

Genetically-modified (GM) crops

As food demand grows and increasing competition for land restricts opportunities to expand farming land, increasing yields from existing land becomes crucial. Arguably one of the main focuses is on the use of genetically-modified (GM) crops whereby hereditary DNA is

augmented by adding DNA from another germplasm source. The incorporation of genes into crop plants to pro duce toxins for pest control will automatically reduce the exposure of non target organisms to these toxins. Transgenic insect resistant seeds could eliminate the need for pesticide application. Biological control agents could also be made more potent by the insertion of engineered toxins. As GM crops are more resistant to pests, weeds, insects and parasites, they give better yields and reduce the need for pesticides. Second-generation GM technologies**,** which are currently under development, are about making crops more resistant to water shortages, extreme temperatures, and saline or acidic soils. Drought and salt-tolerant crops could be of particular interest in the context of fighting climate change, water shortages and soil degradation. At present, transgenics have been developed and commercialized for some 40 crops, including maize, rice, soybean, cotton, tomato, canola as well as fruits, vegetables, and tobacco. Indeed, during the period 1996 to 2003, the global area of transgenic crops increased 40-fold, from 1.7 to 67.7 million ha. Furthermore, 30% of this area is grown in developing countries, where the recent rate of increase has been higher than in industrialized countries **(James, 2003)**. At present, the commercialized transgenics have herbicide (glyphosate) tolerance, and insect resistance conferred by the *Bt* gene from *Bacillus thuringiensis*.. In times to come it is expected that there are many genes for insect and disease resistance in play.

Although no ecological calamities have occurred, it is feared that transgenic crops will develop troublesome new weeds or threaten crop genetic diversity. Necessarily, any new products that pose such risks should be carefully evaluated before they are released for commercial development. But it should be considered that by raising productivity and reducing risks in food production, agricultural biotechnology will reduce the need to cultivate new lands and could therefore actually help conserve biodiversity and protect fragile ecosystems.

Genetic resistance of crop plants to disease

The use of genetically resistant plants is one of the most effective approaches to disease management. Genetic resistance to disease, once secured, is a low-cost method of control. The genetic basis for resistance to a plant disease was first revealed by Biffen (1905). It is more important that it should show the characteristic of durable resistance, since pathogens too tend to evolve virulent variants. About 1%–2%, of a plant's genome is devoted to resistance genes. Such genes often occur in tandem repeats or clusters, suggesting that resistance genes with different specificities arise by gene duplication followed by recombination, gene conversion, and diversifying selection **(Michelmore and Meyers1998).** Typically, this process takes 10 or more years, and by this time, in some instances, the pathogen has already evolved a variant that leads to the susceptibility of the hybrid. The development of Marker-assisted selection (MAS) technique is helping the breeder to curtail the time consuming procedures of screening. MAS allows the pyramiding of resistance genes and is now used in breeding programs for resistance to several diseases **(Kelly et al 2003).**

Trans –boundary movement of plant pathogens and climate change:

Trans-boundary plant pest and diseases refer to organisms that spread across national or geographical (physical) boundaries, indicating that disease or pest events in one country may have direct effects or potential effects in another country. Trans-boundary plant pests refer to quarantine pests. These include pests of potential economic importance to the area endangered, even if they are not yet present, pests that are present but not widely distributed and officially controlled, and migratory pests, in particular locusts, which have the ability to change from individual to collective behavior in swarms that easily cross boundaries. The movement of plant pests, animal diseases across physical and political boundaries threatens food security and creates a global public concern across all countries and all regions.

Countries allocate large resources to limit the spread and control of transboundary pests. Plant pests and diseases reduce food access through reduction of income from animal production, reduction of yields of food and cash crops, reduction in forest productivity as well as increased costs of control. Indirect effects are reduced access to international markets due to the occurrence of quarantine for animal diseases or plant pests.

There is clear evidence that climate change is altering the distribution, incidence and intensity of plant pests and diseases such as plant pests whose distribution is shifting most likely due to climatic factors. Plant pest and diseases are not evenly distributed over the globe, often because they are limited by physical barriers such as mountains, seas and deserts. The increase in movement of people, animals, plants, goods and conveyances has accelerated the redistribution of plant pests and diseases and climate change will create new ecological niches allowing for the establishment and spread of pests and diseases into new geographical areas and from one region to another.

Factors that affect the entry, establishment and spread of plant pests and diseases include:

i). Globalization

ii). Human population growth,

iii). Ecosystem diversity, function and resilience,

iv). Industrial and agricultural chemical pollution,

v). Land use, water storage and irrigation,

vi). Atmospheric composition, CO2 and oceanic acidification by carbonic acid,

vii). Species interactions with hosts, predators and competitors, and

viii). Trade and human movements

These factors are not independent of each other and climate change interacts with each of them. In addition, unforeseen emergence of “new” diseases and pests has been very common. Change in climate resulting in changes in species composition and interactions will augment the emergence of unexpected events, including the emergence of new diseases and pests. Among the major occurrences are the spread of coffee leaf rust throughout the world, soybean rust into America, and citrus tristeza virus in South and Central America and now in the Mediterranean

(Chancellor and Kubiriba 2006). According to **Hardwick, *et al.* (1996), i**ncreased rainfall correlated with a high incidence of canker (*Leptosphaeria maculans*) in oil seed rape, whilst temperature was an important factor in the development of brown rust (*Puccinia hordei*) in cereals. There are a number of quarantine diseases, which might become more serious under global warming, including brown rot (*Ralstonia solanacearum*) and sudden oak death (*Phytophthora ramorum*).Incidences of brown rot in Europe are primarily caused by *R. solanacearum* race 3 biovar 2A, which is reported to have strains adapted to cooler conditions. There are also other phylotypes of *R. solanacearum,* originating from Asia and South America, which would have a greater likelihood of establishment under predicted changes in climate, thereby threatening a much wider range of host plants. **Wright & Woodhall (2006)** considered that the impact of *P. ramorum* might increase through climatic changes producing more optimal conditions for the pathogen. *Dickeya dadantii* (syn. *Erwinia chrysanthemi*, *Pectobacterium chrysanthemi*) is a phytopathogenic *Enterobacteriaceae* that can cause soft rot diseases in a wide range of economically important crops. **Laurila, *et al.* (2008)** reported for the first time that *Dickeya*, originally known as a pathogen in tropical and warm climates, may cause diseases in potato in northern Europe.

Disease management strategies depend on climate conditions. Climate change will cause alterations in the disease geographical and temporal distributions and consequently the control methods will have to be adapted to this new reality. Changes in temperature and precipitation can alter fungicide residue dynamics in the foliage, and the degradation of products can be modified. Alterations in plant morphology or physiology, resulting from growth in a CO_2-enriched atmosphere or from different temperature and precipitation conditions, can affect the penetration, translocation and mode of action of systemic fungicides. Besides that, changes in plant growth can alter the period of higher susceptibility to pathogens which can determine a new fungicide application calendar **(Coakley et al., 1999; Chakraborty & Pangga, 2004; Pritchard & Amthor, 2005).**

Climate change may also result in new transmission modalities and different host species. Drivers of plant pest change include increases in temperature, variability in rainfall intensity and distribution, change in seasonality, drought, CO2 concentration in the atmosphere and extreme events (e.g. hurricanes, storms), intrinsic pest characteristics (e.g. number of generations, minimum, maximum and optimum growth temperature of fungi, interaction with the host) and intrinsic ecosystem characteristics (e.g. monoculture, biodiversity) also affect change.

Impact of climate change on food security

Overall climate change will result in a higher volatility and, therefore, is likely to cause additional crises in local agricultural production with different consequences for socio-economic groups and genders. Plant pests/pathogens and changes in pest/pathogens incidence and intensity may result in additional and inappropriate pesticide use. Changes in rainfall, temperature and relative humidity may favour the growth of fungi that produce mycotoxins and thus may make food such as groundnuts, wheat, maize, rice and coffee unsuitable for human and animal

consumption.

The strategy to address trans-boundary plant pests and diseases is prevention, early warning including forecast, early detection, early control and research. It can be accomplished through better border control and rapid diagnostic tools for better surveillance of plant pests and diseases. In particular, there is a need for better surveillance methodologies; fast and cheap identification methods; epidemiological knowledge; and information on biological control organisms and mechanisms and resistant crops and species. A top priority for dealing with plant pests and diseases is strengthening national plant health services through capacity building. Impact assessment and cost-benefit analyses of adaptation measures at national and regional levels and methods that take a wide range of factors into account should be developed and used in strategic planning **(IPCC 2007)**.

Choosing 'green' agricultural practices

These solutions include integrated pest management, integrated soil fertility management and tillage. The first of the latter options involves using natural predators and parasites to destroy pests, thus reducing the need for pesticides. The second requires combined use of organic and inorganic fertilizers to increase yields, while at the same time improving the quality of depleted soils. Minimum tillage is a conservation tillage method that does not turn over the soil. Plant residues are left on the ground, and seeds are sown through this layer into undisturbed soil. While this means that herbicides need to be used to control the weeds, the method is thought to prevent erosion and help keep soils moist.

Rhizosphere biology and diversity

Agricultural production in many situations cannot be increased without further destroying more areas by turning them into arable land, thus threatening global biodiversity, which is already under stress from human action. If global food production is to keep pace with an increasingly urbanized and growing population, while formulating new food production strategies for developing countries, the great challenge for modern societies is to boost plant productivity in an environmentally sustainable manner.

The development of new crop varieties with enhanced disease and pest resistance, greater drought and salt tolerance and better nutritional value have traditionally focused on plant phenotypes and has largely ignored the role of microbial communities that interact with plants to influence plant health, productivity and biodiversity.

The impact of the microbial world on plants is evident. The important role of nitrogen fixation by rhizobia and other bacteria for plant growth has been known for decades but the omnipresent influence that other microbes have on plant health and growth has largely been ignored. They enhance stress tolerance, provide disease resistance, aid nutrient availability and uptake, and promote biodiversity. A greater understanding of how plants and soil microbes live together and benefit each other can help provide new strategies to improve plant productivity, while helping to protect the environment and maintain global biodiversity. The biological and ecological details that

underpin this phenomenon remain elusive, but these findings suggest that maintenance of a high diversity of plant species requires a correspondingly high level of diversity in the soil microbial community (**Wardle*et al*, 2004**). The soil microbes have a tremendous influence on plant health and productivity **(Bloemberg & Lugtenberg, 2001)**.

Biopesticides:

Realization of the negative effects of agrochemicals on nature and natural resources like pollution, pesticide residue, pesticide resistance etc, have forced many to shift focus on to more reliable, sustainable and environment friendly agents of pest control, the biopesticides. A pesticide that is of biological origin i.e., viruses, bacteria, pheromones, plant or animal compounds is known as biopesticides. They are highly specific affecting only the targeted pest or closely related pests, self- sustaining, do not require in puts from farmers, and is safe for the environment and human health or beneficial organisms while chemical pesticides are broad spectrum and known to affect non-target organisms including predators and parasites as well as humans. Biological control agents seem best suited for the control of exotic or alien pests, which tend to grow in the absence of natural predators in a new ecosystem.

Biopesticides are preferred to chemical pesticides, because they

- Cause less harm than conventional chemical pesticides and do not leave harmful residues.
- Generally target specific pests in contrast to broad spectrum chemical pesticides which affect, apart from the pest, other beneficial organisms like insects, birds and mammals.
- Promote the growth of natural enemies of pests, thus reducing the need for future pesticide application.
- Biopesticides are more effective in smaller quantities and decompose quickly thereby resulting in lower pesticide residues and largely avoiding pollution problems associated with chemical pesticides.
- When used in Integrated Pest Management programs, biopesticides can greatly reduce the use of conventional pesticides, while the crop yield remains high.

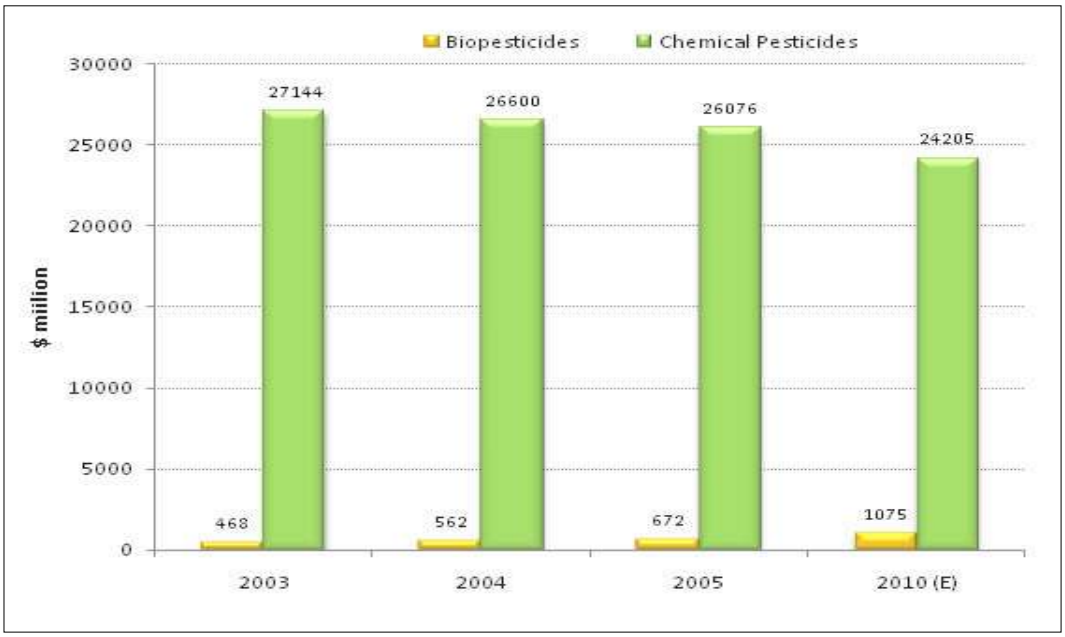
The most commonly used bio-pesticides living organisms (bacteria, viruses and fungi) which pathogenic for the pest of interest include biofungicides (*Trichoderma*), bio herbicides (*Phytopthora*) and bioinsecticides (*Bacillus thuringiensis*). The potential of fungi in controlling pests has been known for some time because they do not have to be ingested by a pest but can infect through physical contact. They are especially useful against root pests, which are difficult to reach and control with conventional pesticides. Fungi like *Phytopthora palmivora* and *Colletotrichum gloeosporioides* have been successfully used in the control of weeds. Also, they are ideal for treatment of seeds. An example is *Trichoderma*, which is effective against root pathogens and is used for seed treatment. First used in 1930, it is one of the oldest and most widely used fungi-based pesticides in the world. Baculoviruses, which include nuclear poly hidrosis viruses (NPV) and granulosis viruses (GV) are target- specific viruses that can infect and destroy a number of important plant pests. In spite of the claimed efficacy, their use, however, has remained very low

due to a number of socio-economic, technological and institutional constraints. Nonetheless, rise in income levels due to a growing economy coupled with increasing awareness of health related effects of chemical pesticides has increased the demand of organic food. In view of this demand and the government's efforts to mitigate climate change, biopesticides are going to play an important role in future pest management programmes. However, some of the factors which have restricted the growth of biopesticides are:

- Low reliability because of low stability in effect
- Target specificity which distracts farmers
- Slow in action compared to synthetics
- Shorter shelf life
- Lack of timely availability of biopesticides in the market
- Already established and strong market of chemical pesticides
- Regulatory system favorable to chemical pesticides

The global weighted average consumption level of biopesticides is approximately 1 kg/ha. With the global organic farming area comprising about 24 million hectares, global biopesticides consumption is thus estimated at about 24 million kg. The biopesticides market is growing very rapidly. In 2005, biopesticides accounted for about 2.5% of the total pesticide market, which was merely 0.2% during 2000. This share is expected to grow to about 4.2% by 2010 while the market value is estimated to reach more than US$ 1 billion (Source: BCC research). However, the overall growth rate of biopesticides is estimated to be about 10% per annum for the next 5 years. In terms of use, orchards claim the largest share (55%) of the total biopesticides used. Region wise, North America consumes the largest share (40%) of the global biopesticide production followed by Europe and Oceanic countries accounting for 20% each (Sinha and Biswas 2008).

Figure 1: Trend of global pesticide vis-à-vis biopesticide market



Source: *Business Communication Company Inc.*

Regulatory methods/ plant quarantine:

Plant disease regulations are designed to facilitate trade while reducing the risk of international movement of restricted organisms whose introduction could require expensive eradication or control operations. It is the responsibility of National Plant Protection Service to protect their countries from the unwanted entry of new pathogens and pests and to systematize programs to eradicate those that have recently arrived and are still sufficiently confined for their elimination to be realistic. Regional plant protection organizations play a role in coordinating such "phytosanitary" activities across a region **(Smith et al, 1996),** and the Secretariat of the International Plant Protection Convention has a global responsibility in this field. In recent years, the identification of risk has been formalized, because transparent justifications of phytosanitary measures are required and phytosanitary measures have to be commensurate with the risk. The aim of the plant protection organizations is to help its member countries to prevent entry or spread of dangerous pests (plant quarantine). The Organization therefore takes the task of identifying pests which may present a risk, and of making proposals on the phytosanitary measures which can be taken. But, considering the enormity of the ecological regimes in India and the dynamics of the international agri-trade policy, plant quarantine regulations would be constrained due to the increased possibilities of the spread of pathogens. Preventive domestic quarantine needs to be considered along with strict Pest Risk Analysis (PRA), so that aggravated risk to ecological biodiversity and cost of plant introduction could be reduced.

d in developing countries as well.

Integrated pest management

Over-reliance on the use of synthetic pesticides in crop protection programs around the world has resulted in disturbances to the environment, pest resurgence, pest resistance to pesticides, and lethal and sub-lethal effects on non-target organisms, including humans**.** These side effects have raised public concern about the routine use and safety of pesticides. At the same time, population increases are placing ever-greater demands upon the “ecological services”—that is, provision of clean soil for sustainable agriculture, air, water and wildlife habitat. Farmers will be required to manage their land with greater attention to direct and indirect off-farm impacts of various farming practices on soil, water, and wildlife resources **(Dufour 2001)**.

Sustainable agriculture is a system of agriculture that is ecologically, economically, and socially viable, in the short as well as long term. Rather than standing for a specific set of farming practices, a sustainable agriculture represents the goal of developing a food production system that:

1. Yields plentiful, affordable, high-quality food and other agricultural products
2. Does not deplete or damage natural resources (such as soil, water, wildlife, fossil fuels, or the germplasm base)
3. Promotes the health of the environment

4. Supports a broad base and diversity of farms and the health of rural communities
5. Depends on energy from the sun and on natural biological processes for fertility and pest management and
6. Can last indefinitely

There is consensus that indiscriminate, excessive, and inefficient use of pesticides exacts too high a toll in terms of human health, environmental safety, and ultimate diminishing returns to justify any short-term increases in farm income or food output.

IPM and sustainable agriculture share the goal of developing agricultural systems that are ecologically and economically sound. IPM may be considered a key component of a sustainable agriculture system. A premise common to IPM and sustainable agriculture is that a healthy agro-ecosystem depends on healthy soils and managed diversity. There is no consensus about the meaning of IPM **(Miguel 1994).** Understandings range from pesticide-free ecological agriculture to a range of efforts to use chemical pesticides more judiciously and usually as a last resort, in combination with other pest management approaches (hence the "integration"), with more careful scouting for pests/diseases and improved targeting of pesticides/ fungicides when they are used. Biointensive IPM incorporates ecological and economic factors into agricultural system design and decision making, and addresses public concerns about environmental quality and food safety. The benefits of implementing biointensive IPM can include reduced chemical input costs, reduced on-farm and off-farm environmental impacts, and more effective and sustainable pest management.

IPM must be science-based and economically viable for farmers giving the main emphasis on anticipating pest/ disease problems and preventing them from reaching economically damaging levels.

A systems approach to IPM is based on an understanding of pest ecology. It begins with steps to accurately diagnose the nature and source of pest problems, and then relies on a range of preventive tactics and biological controls to keep pest populations within acceptable limits. Reduced-risk pesticides are used if other tactics have not been adequately effective, as a last resort, and with care to minimize risks **(Benbrook 1996).**

Teaching plant pathology for global food security:

Despite an urgent need to feed an increasing population, there is a general decreasing role of agriculture, which is strictly connected with a poor understanding of agriculture and science amongst the general public. Mostly there is a lack of literacy of the public and, even worse, of many policy-makers. The teaching environment for plant pathology is changing in both positive and negative ways. Teaching expectations are increasing and resources are decreasing, but recent educational research and instructional technology offer new approaches to meet these challenges. Plant pathologists are teaching courses that may attract new students to the discipline or at least improve agricultural awareness. Teaching plant pathology and plant disease management today is confronting with both negative and positive challenges. Smaller numbers of

undergraduate students are attracted to sciences in general: as a consequence, an even smaller number of students are attracted to agricultural sciences. The decreased enrollment of students in agriculture is accompanied with declining student numbers as well as interest in plant pathology. Plant pathology remains a critical topic, and teaching plant pathology, because of its complexity, remains a major challenge for both teachers and students.

New technologies are now available for teaching. More links with Scientific Societies are needed. The International Society for Plant Pathology has a Subject Matter Committee on teaching and the topic of teaching has been well covered during its International Congresses. The American Phytopathological Society has in place very successful programmes, with its APS-net Education Center and established an ad hoc Committee dealing with education of plant pathologists, which prepared a very complete analysis of the present situation in the United States. A new generation of students adaptable to future changes, capable of critical thinking, flexible and able to communicate and work as a team, must be trained.

It will be important to get plant protection and social role of diseases into early curriculum, also bringing plant pathology teaching into Sciences and Environment Colleges. Bringing plant pathology into biology and microbiology courses can enrich the education of these students, by introducing new and fascinating topics, which are closely related to food quality and safety and environment protection.

Knowledge and technology transfer for plant pathology:

Good communication is essential for all plant pathologists. Plant pathologists must be able to communicate their findings and advice with equal facility to growers ranging from subsistence farmers to those cultivating thousands of acres, whose level of understanding of the causes and control of plant disease may vary widely and whose aspirations and priorities may range from simple survival to the payment of a large dividend to shareholders. They must also be able to teach disease diagnosis to field practitioners and advisors. And finally, in colleges and Universities, they must train the next generation of plant disease specialists. Perhaps the most important change with regard to communication in plant pathology since 1968 is the availability of computers and widespread access to the internet, giving benefits ranging from easy and rapid access to published information, through computer simulation, to distance learning and teaching across countries.

The molecular biological research on plant diseases, not least on crown gall, of the last decades of the 20th century has given us, amongst many advances, rapid and accurate diagnostic tests and the application of plant genomics in breeding for disease resistance in the 21st century. The work of a new generation of researchers will, no doubt, bring equally significant practical advances to plant pathology in the future. Despite the increasing complexity of technical language and the massive explosion of information, it is essential that communication between the different disciplines within plant pathology is significantly enhanced, in all directions, if scientific advances are to be translated into technological innovation with a minimum of delay **(Ingram, 2011).**

Public education, extension and outreach

Extension plant pathologists have been the face of our science to farmers, horticulturalists, homeowners, and agribusiness. Extension work in plant pathology was first undertaken by state land grant university or college faculty in the context of county fairs, farmer institutes, short courses, field demonstrations and other efforts to deliver information to the above mentioned clientele. The concept was to help diffuse among the people practical information on subjects relating to agriculture and home economics and to encourage application of the same by giving instruction and practical demonstrations in agriculture to communities and imparting to such persons information on said subjects through field demonstrations and publications. Until the late 1950s, the majority of extension plant pathologists focused on disease problems influencing food production. But with time as extension methodology and clientele have evolved, so have the means by which they deliver the information. One major change is the internet, which has made extension bulletins, newsletters, and diagnostic keys available to the general public and other interested parties on a regular basis. This has changed the face of current Plant Diagnostic Information System (PDIS).

In order to reach out to larger masses, an extension plant pathologist must be creative with hands-on activities, the use of videos for information delivery, and other interactive activities. While there are many new tools for extension specialists to use in educational programs, it is still critical that the farmer clients of extension plant pathologists have face-to-face access on a regular basis, if they are to have confidence in their ability to understand their client's problems and make sound recommendations.

Structural and non-agricultural use of pesticides represents a significant source of environmental pollution of surface waters, ambient air and an unknown risk to these pesticide users. We know that the public, once reached, is interested in IPM and reducing pesticide risk. Most of the time, the written information on pest management is unable to attract or hold the attention of general public. Reducing the pesticide load in the environment require a multi-faceted, long-term effort of public education and outreach.

During recent years, there has been a noticeable increase in formal and informal training programs about sustainable agriculture in all regions of the world. The trainings must explore crop management options including seed treatment, crop protection inputs, tillage practices, planting dates, application timing, soil compaction, nutrients and plant health. The interactive education programmes for farmers, extension technicians and advisers should be aimed at developing broad-based understanding rather than simply to introduce alternative technologies or practices or less toxic crop protection chemicals. The concept of Farmers Field School originally developed in Indonesia for controlling pesticide-induced outbreaks of brown plant hoppers in irrigated rice has been very successful and widespread to all parts of the world including India. Though the details are different in each country, they share some key characteristics such as being farmer-centred, using experiential learning in groups and are based on adult education principles. The Farmers

Field School concept was introduced into Europe, with FAO support, to help farmers in central and Eastern Europe to understand and apply IPM options for dealing with western corn rootworm (WCR) that spread rapidly in maize-growing areas in the 1990s.

Mobile Plant clinics are a comparatively newer concept where the clinics are staffed by IPM-trained technicians who provide direct diagnostic assistance to farmers who bring samples of affected plants and insects for identification. When a diagnosis cannot be made immediately, samples are sent to laboratories and the results are available on the clinic's next visit **(www.gpc.org).**

The long-term development of a sustainable IPM program also requires strong leadership and cooperation among user groups and the linkages between these groups and the wider community. The interactions of the people involved in IPM are the key to the success or failure of the program. When the respective roles of all the people in the pest management system are identified and when these people communicate well with each other, effective and less expensive plant protection can be achieved with fewer risks. In addition, full implementation of a well-understood IPM approach will create a more efficient and safe environment, saving time and money and increasing worker safety.

Traditional agriculture and food security

Since recorded history, the impact of pests on different crops has been important as a result of which many practices of "traditional" and "modern" agriculture have evolved. During the last century high input biased intensification of agricultural production and less diversified farming systems has caused crop protection problems to multiply. As a result of the increasing need for methods to prevent losses due to pests, an impressive array of crop protection technologies such as pest-resistant plants, cultural controls, biological controls, pesticides, behavior-modifying substances, quarantine laws, and pest eradication programs have evolved. Some cultural controls are not adaptable to high-production agriculture: some pesticides have declined in effectiveness: other controls are used successfully to manage only a limited number of pests: none are entirely satisfactory or universally applicable.

Ancient farmers developed sustainable agriculture practices which allowed them to produce food and fibre for thousand of years with few outside inputs. Most of such practices were developed empirically through millennia of trial and errors, natural selection, and keen observations. Some of these practices which often conserve energy, maintain natural resources and reduce chemical use, deserve examination (Thurston, 1990). Today, perhaps over half the world's arable land is farmed by traditional farmers. Many of their techniques are unknown or poorly understood, but have allowed them to produce crops and animals with minimal or no purchased inputs. The striking diversity existing in the traditional farming systems gives them a high degree of stability, resilience and efficiency especially on marginal lands.

High yields of modern intensive agriculture have made it possible for the ever increasing human population to be fed without the extensive destruction of habitats to provide the needed

food. Unfortunately, this has been accomplished at the expense of the surrounding ecosystem. The challenge for the future is how to increase yields in traditional systems while retaining a certain measure of their integrity.

Efforts to intensify agriculture production will continue as a result of the need for food security among rapidly growing population. But changes in agricultural systems and in the intensity of land use have impacts on pest problems. Growing food demand must to be met primarily by increasing production on land already under cultivation (productive and marginal lands) and by reducing losses due to diseases and pests. Attention, therefore, must go to small and marginal farmers, who till nearly 65% of world's arable land, to increase farm productivity. By their numerical strength, small and marginal farmer form the majority (~80%) of cultivators in India. There is need to improve the efficiency and economics of small farm agriculture. In the words of Dr. M.S. Swaminathan "A Small Farm Management Revolution is the pathway to achieving the **UN Millennium Development Goal** relating to the elimination of hunger and poverty". The science of Plant Pathology has an important role in the future success of programmes and policies designed to increase and sustain food production.

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Alternative to Methyl Bromide

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Chemical which at required temperature and pressure can exist in gaseous state in sufficient concentration to be lethal to a given pest organism

- The main area of use of fumigation lies in the control of insects, their eggs, larvae and pupae in the stored produce. As the fumigants are highly toxic to mammals, treatment also has a useful side effect on rodents.
- This also means, however, that fumigants are extremely toxic to humans and that therefore fumigations should only be carried out by well-trained staff.
- Correctly applied, fumigants are entirely successful. The tiny gas molecules easily penetrate large stacks of grain right into the individual grains, reaching and killing all stages of development of the pests.
- Gases do not have any long-term effect due to their high volatility.

Areas of Application for Fumigants

- The most important areas of application for fumigants are the treatment of bag stacks in stores or bulk grain in silos. Additionally fumigants are used in sealed chambers, gas-tight containers or wagons to desinfect produce.
- When fumigating a bag stack, it is necessary to cover the stack with a gas-tight sheet and hermetically seal it, thus ensuring that the required concentration of gas is maintained for the entire exposure period.
- Treatment of an entire warehouse can only be carried out when the structural conditions enable the store to be tightly sealed. Most stores do, however, have gaps or cracks in critical places, such as along the joint between the roof and the walls, making space fumigation impossible. There are only very few fumigable stores in the world.
- Special fumigation chambers are excellently suited for the treatment of smaller amounts, but these are often not available on the spot. Stack fumigation therefore is the most practicable and convenient method in most cases.

Choice of fumigant

- Non-corrosive
- Non-reactive
- Physiologically inactive
- Non-flammable
- Non-explosive
- More toxic to pest
- Less toxic to warm blooded animals
- Good penetration and diffusion

Fumigants

- Phosphine
- Methyl Bromide
- Ethylene dibromide
- Ethylene dichloride
- Carbon disulphide
- Carbon tetrachloride
- Ethylene dichloride + Carbon tetrachloride
- Dichlorvos
- Acrylonitrile
- Chloropicrin

Mainly two fumigants are used in pest control: Phosphine (PH_3) and Methyl Bromide (CH_3 Br). So phosphine can be used as alternative to methyl bromide.

Phosphine

Properties

- Very good penetration of stored produce, can even penetrate brickwork
- Spreads well in enclosed spaces
- Disperses rapidly on ventilation after fumigation
- Has generally no negative effect on germination capacity
- Leaves no gaseous residue after ventilation
- Has carbide or garlic-like smell which serves as warning agent. In case of frequent dealing with phosphine, however, this is not always noticeable
- Acts relatively slowly
- Is self-igniting if present in high concentrations in the air (higher than 1.8 , vol.)
- Corrodes copper e.g. electrical cable and contacts

Toxicity of Phosphine

- Phosphine is effective against all stages of development of insects (eggs, larvae, pupae, adults).
- Phosphine is highly toxic to warm-blooded animals, and is thus very dangerous to human beings.
- There have been no known cases of chronic poisoning as a result of repeated intake of sub-lethal doses.

Formulations

- Phosphine is available as aluminium phosphide (AlP) and as magnesium phosphide (Mg.P.).
- Magnesium phosphide liberates phosphine more completely and more rapidly at temperatures below 20°C than aluminium phosphide does.
- Both formulations are available in various forms and packs, as follows:

- Tablets: Each weigh 3 g and yield 1 g of PH
- Pellets: Weigh 0.6 g and yield 0.2 g of PH
- Bags (sachets -only as aluminium phosphide): Contain 34 g of preparation and yield 11.3 g of PH. They are sold individually, in bag chains (10 connected bags) or in bag blankets (with 100 bags). The bags are ready for use -never open them!
- Plates (only as magnesium phsophide): Weigh 206 g and yield 33 g of PH.. They are sold individually or in strips contaning 16 plates.

- All phosphine formulations are ready-for-use in the forms described above.

Forms of Packaging

- 10 tablets of 3 gms each x 16 tubes x 36 tins in one CFB box.
- 20 tablets of 3 gms each x 16 tubes x 20 tins in one CFB box.
- 0.6 gm pellets x 1 kg in a bottle x 20 bottles in one CFB box.
- 10 gms pouch x 500 pouches in a tin x 15 tins in a case.
- 34 gms pouch x 100 pouches in a tin x 4 tins in a case (in belt or loose packing).
- 34 gms pouch x 20 pouches in a tin x 12 tins in a case (in belt or loose packing).
- 34 gms pouch x 10 pouches in a tin x 24 tins in a case.

Generation of Gas

- Phosphine (PH3) is generated as a result of temperature and moisture (in the air) reacting with the solid aluminium or magnesium phosphide. In the case of sachets the generation of gas is slowed down because of the absorbtion of humidity by the sachet itself. This should be borne in mind when determining the duration of the exposure time.
- The generation of gas starts immediately when the container holding the fumigant is opened. Anyway, concentrations which are likely to be dangerous to humans are not reached until at least one hour later. This period may be even longer if the temperature and the relative humidity are low.
- The decomposition of the formulations is never complete. Only approximately 98 % of the phosphine is liberated during fumigation. The powdery residue still contains 2 % of unreacted aluminium phosphide (or 0.2 % in the case of magnesium phosphide) and must be collected after fumigation. Tablets and pellets therefore should be placed on a sort of tray or piece of cartboard. The powder is disposed of by pouring it into water mixed with a detergent, thus fully liberating the gas. This should be done in the open air in order to avoid the inhalation of the fumes!

Chemical reaction when generating phosphine:

AlP	+	3 H_2O	PH_3	+	$Al(OH)_3$
Aluminium phosphide	+	Water (atmospheric humidity)	⟶ Phosphine	+	Residue (greyish powder)

Magnesium phosphide $Mg_3P_2 + 6\ H_2O \longrightarrow 2\ PH_3 + 3\ Mg(OH)_2$

Factors Influencing the Success of Fumigation

Recommended Application Rates

- Aluminium phosphide 56% tablet (3g) 1-2 tablet per tonne or 14 tablet/28 m3.
- Aluminium phosphide 15% tablet (12g) 1-3 tablet/ ton or 600-900g/100m3
- Aluminium phosphide 56% Fumigation Bag 1 bag of 10g/5 qtl. grain
- Aluminium phosphide 56% Fumigation Bag 1 bag of 34g/15 qtl. grain
- The rate may vary from region to region due to resistance in insect pests.
- The concentration of gas initially established first leads to the insects being narcotized before they are finally killed. The resulting reduction in their respiratory activity means that they take in less of the gas. Should the gas concentration drop rapidly as a result of insufficient sealing or damaged tarpaulins, the pests will reawaken after a certain period without having received a lethal dose.
- Good sealing is the most important fact when fumigating as this will lead to excellent success.

Exposure Time

- The minimum exposure time depends on the temperature, the relative humidity and the formulation used, and on whether there is any resistance against phosphine.
- Under normal condition exposure period of 5 days is sufficient.
- With a relative humidity of below 60 % up to 6 days and more
- In case of resistance: at least 3 days more in each case
- Fumigation is ineffective if the relative humidity is below 30 %.
- When mites are present, a minimum exposure period of 10 days is required.
- The lower the temperature and/or the relative humidity, the slower the chemical reaction to generate phosphine and the longer the exposure times required will be.
- Under arid climate conditions the relative humidity under a sheet may be raised by placing bowls of water beneath the pallets or by sprinkling water underneath the pallets.
- However, under no circumstances must the fumigant come into direct contact with the water.
- The basic principle is -the longer the gas is able to act, the better is the success. This, however, presupposes that the stored produce is perfectly sealed during the entire fumigation.

Sealing

- The most important prerequisite for the success of fumigation is the quality of the sheet and the sealing in order to maintain the necessary concentration of gas for the entire exposure period.

Fumigation sheets

- A fumigation sheet has to meet specific requirements:
  -highly gas-tight (including any seams)

-sufficiently resistant to tearing

-of low weight (max. 200-250 g/m^2)

-highly resistant to ultraviolet light and temperature

- Many plastic materials do not fulfill these requirements as they are either not sufficiently gas-tight and resistant to mechanical damage or to heavy for handling.
- The strips of the sheet should be welded together and the edges of the sheet additionally reinforced to prevent them from tearing apart.
- Sheets with glued seams are not always able to withstand tropical weather conditions. Stitched seams cause gas loss due to the holes made by the needle on sewing.
- The size of the sheet should be selected so as to enable fumigation of one stack with a single sheet. Standardized stack sizes are of considerable advantage.

Care of fumigation sheets

- Good storage and careful handling prevents damage and extends the life of fumigation sheets. They should be folded together neatly and stored on pallets. If the sheets are carelessly thrown in a heap in the corner of the store, rodents may use them as nesting sites and severely damage them.
- When placing the sheets over the stacks, care should be taken to avoid any holes or tears. Do not drag sheets along the ground or over pallets, but carry them instead! Do not walk on the sheets when folding them up, as small stones and grains will make holes in the sheets.
- The sheets must be checked regularly. Any holes or tears must be repaired immediately. Small tears can be sealed using insulating tape on both sides of the sheet, and larger ones by sticking a piece of sheet material over them. A special adhesive may be required for this.

Material for sealing the fumigation sheet to the floor

- Even the best quality sheets are of no use if they are not well sealed to the floor. The best-proven method is to use sand snakes, which has a number of benefits:
    - high flexibility (good adaptation to the floor)
    - sufficient softness (no damage to sheets)
    - sufficient weight (to keep the sheet pressed to the floor
    - easy to make
- The following materials are required to make sand snakes:
    - old grain bags cut in half or thirds lengthways and stitched together at the cut edges
    - dry coarse sand
    - old fumigation sheets or tarpaulins cut into suitably sized pieces and stitched together in a sausage shape
    - hose foil: supplied in running metres which can be cut into suitably-sized sections and the ends knotted or welded.

- Sand snakes should have a diameter of at least 10 cm and be 1 -1.5 metres in length. Fill them with just enough sand to enable them to bend and to adapt to any uneven areas of floor. Never fill sand snakes tightly as they will get to rigid to fulfill their purpose.
- Sand snakes should be placed so that they overlap by at least 1/4 of their length.
- Stones, palettes, wooden beams or other similar materials are unsuited as they are not flexible enough and may damage the sheets. Never use bags filled with stored produce for sealing purposes as they may be infested and provide a starting point for re-infestation.
- A further method of sealing is the use of paper and paste. A pre-requirement for this type of application is a smooth and well cleaned floor. Mix a thick paste of water with wheat flour. Wallpaper paste is even better if it is obtainable. Spread a coat of paste in those areas where the sheet will be layed on the floor. Lay strips of paper 15 -20 cm wide on top of this coat and cover them as well with paste. Place the sheet along the centre of the paper strips, coat it again with paste and place a further layer of paper on top of it. Finally give the upper layer of paper a further coat of paste. When the paste dries, you will have a lasting, gas-tight seal.This method does not apply to the corners of stacks where folds form. Sand snakes have to be used here.

Application

- It has already been mentioned that for safety reasons, residue from tablets, pellets and bags must be collected after fumigation. While this is a simple matter with bags, there are difficulties involved in collecting the powdery residues from tablets and pellets. Tablets and pellets must therefore be placed on trays or pieces of cardboard and never simply distributed on the stacks.
- Egg-boxes provide the best trays, as a single tablet can then be placed in each segment. Wooden planks with holes drilled in them just large enough to take a single tablet or pellet also make excellent trays. Wooden planks from old pallets may be used to make these.
- Place the trays/cardboards under the pallets, distributing them evenly, or directly at the side of the stack before sealing.
- As there is a danger of self-ignition with large concentrations of phosphine, tablets and pellets should not touch each other.
- Chains of bags should be used in preference to single bags. These are then attached to the stack by wedging the first bag of the chain between two bags of grain in the stack.

Ventilation

- At the end of the fumigation process, the fumigant must be thoroughly removed from the stored produce and the store by means of extensive ventilation before the store can be released again for general access.
- The minimum ventilation period for phosphine is three hours.
- Where aeration is reduced due to a lack of ventilation facilities, the period must be extended to at least six hours.

- If there is no gas detector available, the ventilation period should be extended to 6 -12 hours in order to avoid any risks.

Resistance to Phosphine

- Correct execution of fumigation will lead to complete control of storage pests so that there is generally no possibility of resistance developing.
- Poor fumigation practices have, however, led to resistance against phosphine to alarming proportions worldwide, and the tendency is increasing.
- Resistance to phosphine was first discovered in countries in which space fumigation was performed in stores which were not gas-tight.
- Today it is an undisputed fact that the development of resistance in storage pests is particularly favoured by poor sealing and the resulting loss of gas. When the gas concentration drops too rapidly the pests have the chance to survive and to reproduce.
- The following measures should be taken:
    - Good store hygiene and management
    - Correct dosage and application of fumigant
    - Complete sealing of the stored produce or store to be fumigated
    - Sufficient exposure time

Fumigating a Stack of Bags with Phosphine

- Fumigation work must only be performed by trained staff. For each fumigation, one person is responsible as head of the fumigation tea. from preparing the fumigation to the release of the store for general access. The head of the fumigation team is responsible for the success and safety of the fumigation.
- The fumigation of bag stacks can be divided into 5 steps:
    - preparations
    - application of the fumigant and sealing
    - controls during fumigation
    - ventilation and release of the store
    - cleaning up work
- The safety regulations and instructions provided by the fumigant manufacturer followed during the entire fumigation process.

Preparations

- Inform all people who work in the store and all those who live in the vicinity of the store about the forthcoming fumigation!
- Ensure that there is no danger to residents!
- Clean the store!
- Measure the length, breadth and height of the stack:
- Calculate the volume of the stack:
- Calculate the number of tablets, pellets or bags in accordance with the recommended

application rate

- Round the number up or down according to the size of the packs in order to use up all open tubes (with 30 tablets/tube use 5 tubes of 30 tablets = 150 tablets).
- Check the folded sheets for damage!
- Spread the fumigation sheet over the stack as follows:
    - Place the folded sheet on the stack !
    - Unfold the sheet over the sides of the stack
    - Pull the sheet over the stack so that at least 1/2m is on the floor on all sides !
    - When covering the stack with more than one sheet:
        - Roll the sheets together so that they overlap by at least 1/2 m!
        - Keep the rolled part together with clips or with sand snakes on top and adhesive strips at the sides
    - Distribute a sufficient number of sand snakes around the stack!
    - Evenly distribute the closed fumigant containers around the stack so that they are at hand; e.g. 1 tube with 30 tablets next to each tray/cardboard
    - Keep a breathing mask with a new filter ready in case of emergency!

Application of the fumigant and sealing

- When using tablets or pellets:
    - Open the containers, tubes or flasks one after another and distribute the tablets or pellets on the trays / cardboards without touching each other!
    - Lift the side of the sheet and push the trays/ cardboards under the pallets!
- In case that pallets are not available for any exceptional reason, place the trays/cardboards on the floor next to the stack.
- When using bag chains:
    - Open one tin of bag chains after another and fix the bag chains at regular intervals by pushing one bag between two bags of grain in the stack
- Unfold the fumigation sheet smoothly over the stack
- Place a sand snake
- Fold the sheet over the edge of the stack
- Ensure that the sheet is lying flat on the ground!
- Distribute the sand snakes on the sheet around the stack so that they overlap for 1/4 of their length!
- All work has to be performed in order to be finished within one hour due to the ensuing generation of gas.
- If the stack is built on a porous or sandy floor, a sheet must be already placed underneath in the moment of stacking to prevent the gas from escaping into the ground. Fasten it to the sheet covering the stack at the side as shown above in the section on preparations for fumigation.

- Attach warning signs to the stack and to the door of the store!
- Lock the store!

Controls during fumigation

- Make a regular check of the seals!
- Ensure that no unauthorized persons enter the store during the entire fumigation period!
- Only allow the most essential work to be performed in the store and care for good ventilation when work is taking place! Measure the concentration of the gas from time to time in order to ensure that there is no danger to staff!

Ventilation and release of the store

- Open doors and windows to ventilate the store!
- Wear a mask with a new filter (Type B) for phosphine!
- Remove the sand snakes!
- Turn up the sheet at the corners of the stack!
- Leave the store and ventilate for at least one hour (the longer the better)!
- Remove the fumigation sheet from the stack completely (wearing mask)!
- Ventilate for at least a further two hours (the longer the better)!
- Measure the phosphine concentration in the store wearing a mask and release the store for general access if the reading is below 0.1 ppm, or continue ventilating if the concentration is still above this level!

Cleaning up work

- Collect the residues of the tablets, pellets or bags!
- Dip the powdery residue of tablets and pellets into water mixed with a detergent and take care not to inhale the fumes!
- Rinse out empty phosphide containers (cans, tubes, bottles) with water, destroy them to prevent reuse, and bury them!
- Bury used fumigant bags or bag chains!
- Check the sheet for damage and repair it if necessary!
- Fold the sheet together properly as follows:
    - Lay together both edges to meet at the middle until you have reached a width of 1 - 1.5 m on either side of the centre line. Then fold the sheet in half first crosswise, then lengthwise and roll it up!
- Store the folded sheet on a pallet !
- Remove the warning signs from the doors!

Fumigating Silos Using Phosphine

- Silos can best be fumigated during filling. Care must be taken to seal all openings with kraft paper and paste, or with impermeable coverings. The fumigant is added to the produce on the conveyor belt at regular intervals or thrown into the silo from above through a hatch during filling. This is done in line with the quantity of loaded grain.

- Example:
    - A silo with a capacity of 500 tons is to be filled completely. This is being carried out at a rate of -20 t/h.With a dosage of 3 tablets/t, 60 tablets would have to be added every hour. It would be practical to add 5 tablets every five minutes to ensure good distribution of the gas.
- If an automatic dispenser is available, it should be set at 1 tablet per minute.
- Automatic dispensers are available both for tablets and pellets.
- As the filling of a silo takes a considerable time, the staff may be endangered by the generation of gas. Therefore masks must be used when the fumigant is applied manually.
- If a silo is not being filled completely, additional fumigant must be applied in line with the remaining silo capacity (m3).
- The residues of the fumigant must be removed from the stored produce before it is forwarded:
    - Bags are collected at the grain outlet by being caught in a large-meshed screen.
    - Tablet and pellet residue is removed using an aspirator.

Fumigation of Bulk Produce with Phosphine

- Bulk grain can also be treated under a fumigation sheet.
- Fumigation should be performed in line with the instructions for bag stack fumigation.
- If the height of the bulk produce is less than 2 metres, tablets, pellets (on trays) or sachets may be distributed onto the stored produce at regular intervals and collected again after fumigation. Blankets (1 blanket for each 100 - 300 t) are particularly well-suited for this purpose.
- If the height of the pile is over 2 metres, then tablets, pellets or narrow bags must be probed into the produce at regular intervals. This requires good preparation and a good team, as it should take no longer than one hour from opening the first container with fumigant to the final seal being made.
- The residue can only be taken out in such cases by means of mechanically cleaning the bulk produce when it is removed from the store.

Tolerance limit

- Food grain 0.05ppm
- Milled food grain 0.01ppm

Eco-friendly Management of Diseases for Safe Storage and Export of Oilseeds

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The diverse agro climatic conditions of India are well suited for cultivation of annual oilseed crops such as Groundnut, Soybean, Rapeseed-mustard, Sunflower, Niger, Safflower, Sesame, Linseed and Castor. These commodities of crops are the second largest next to cereals. They occupy about 13.5 % of the gross cropped area in the country and account for 5% of the gross national product and 10% of the value of all agricultural products. The seeds of these crops stored for various purposes as for source of seed, for the purpose of value added products for food (edible oil) and feed (oil cake), for confectionery products. Hence the loss of grain spoilage of various oilseeds in storage is quite common and the losses in storage may be either quantitative and/or qualitative primarily due to an inability of effectively controlling physical and biological factors. These losses are largely the result of the external biodetergents (storage fungi, insects, and rodents), temperature, relative humidity and seed moisture content.

The quantitative losses in these commodities as oilseeds have been established to be to the extent of 20% with an average of 10%. Groundnut and soybean losses may be much greater. Storage losses at farm level in oilseeds may be in the range of 35-50% followed by 10-12% in traders stores and further of 5% in central stores. Storage losses in oilseeds are also reflected through reduction in oil content and oil quality in terms of colour, increased free fatty acids, iodine number and development of oxidative rancidity.

Mycotoxins contamination of oilseeds particularly of aflatoxins produced by *Aspergillus flavus* posses severe health hazards to humans and animals and affects international trade in oilseeds and their products.

Storage methods of oilseeds

Storage of oilseeds in India is mostly traditional and these are stored in variety of structures such as: earthen pots, mud bins, bamboo baskets, gunny bags made from locally available materials. Bulk storage of oilseeds is usually practiced by traders, oil millers and processors of oilseeds in various containers. Silos are also used on a limited scale for bulk storage of oilseeds particularly soybeans by the Oil Federation of different states and food corporation of India.

Traditional storage structures used in rural areas are neither rodent proof nor secured from fungal and insect infestation. Other factors influencing quality of seeds during storage include initial seed quality, damage caused by rough handling, the extent of cleaning of crop produce, moisture content of the seed, temperature and relative humidity conditions of storage systems.

Storage problems in different oilseeds

Groundnut

Groundnut used for seed need to be stored for 7 to 8 months and the nuts intended for

edible purposes may be stored until the beginning of the next harvesting season. Several fungi become associated with groundnut seeds in storage particularly when the moisture content of the seed is more than 7%. Predominant fungal species that deteriorate groundnut seeds in storage are *Aspergillus flavus* (group *oryza*), *A.niger, A.repens, A.chevalien, A.restricta, A.tamarii, Penicillium citrium, Botryodiplodia*, *Cladosporium herbarum*

The shelled groundnut kernels are particularly affected by Red rust flour beetle (*Tribolium castaneum*) and *Trogoderma granarium*. Insect infestation predisposes groundnuts to mould attack. Of the various storage structures used, high seed damage and low germination have been reported in plywood and metal bins, but polythene bags and earthern pots have been found to be quite satisfactory in minimizing the seed damage in storage.

Aflatoxin

Aflatoxins are produced by toxigenic strains of *Aspergillus flavus* and *Aspergillus parasiticus* fungi in various foods and feeds. Aflatoxins are highly toxic metabolites. These meatabolites being carcinogenic, mutagenic and immuno-suppressive pose serous health hazards to humans and animals. Out of the 4 components of aflatoxin (B1, B2 G1 and G2) –B1 is the most potential carcinogenic. A large number agricultural commodities like groundnut, maize, Jowar/Basra, chilly, Cashew nuts, almond, black pepper etc. are often get contaminated with aflatoxin. Aflatoxin contamination depends on growing seasons and situations. Accordingly status of aflatoxin is different in different production environments in the country. At pre-harvest stage, prolonged drought/moisture stress (3-4 weeks) at pod maturity associated with high temperature (350C-400C), over maturity and mechanical and biological (soil pests) damage of pod leads to aflatoxin contamination. Aflatoxin contamination is due to certain problems at pre and post harvest levels. Delay in drying process, storing of produce at higher pod moisture (12% and above) along with damaged pods and high relative humidity, etc. promote mould growth and thereby toxin production. Thus maturity level of the produce, initial seed moisture at the time of bagging and storage condition (temperature and humidity) are major determinants for aflatoxin build up in the stock.

Reports on Aflatoxin Hazards to Humans and Livestock

Over one lakh Turkey poultry birds died in England after consuming aflatoxin contaminated groundnut meal from Brazil. The disease was named as Turkey ‘X’ diseases. Aflatoxins have been responsible for causing acute disease out breaks called aflatoxic hepatitis of Gujarat and Rajasthan in India, central Kenya in Africa and Malaysia that was due to consumption of mould infected maize. Indian childhood cirrhosis (ICC) a liver disorder found only among children is also caused by aflatoxin. Outbreaks of aflatoxicosis in animals and poultry birds have been recorded in India.

Permissible Limits for Aflatoxins in Different Countries

Country	Commodity	Limit ppb.
Australia	Groundnut	15

Belgium	All foods	5
Canada	Nuts & Nut product	15
China	Rice and other cereals	50
India	All foods	30
France	All foods	10
UK	Nuts and Nut products	4
US	All foods	20

More precisely the safe levels of aflatoxins in food and feed purposes are:

Sl. No.	Purpose	Limit ppb.
1.	Human consumption	20
2.	Cattle/Poultry feed	100
3.	Groundnut (unsorted)	5 B1 10 B1+B2+G1+G2
4.	Groundnut (sorted)	2 B1 4 B1+B2+G1+G2
5.	Milk	0.05 B1

Groundnut is a unique food legume “ready to eat” right at harvest either as raw/roasted or through to several forms of value addition/fortification in daily diet. The nuts contain 30% protein, 48% fat and 15% carbohydrate besides vitamins (Foliate, Vitamin E, Niacin, Thiamine, Riboflavin, etc.) and minerals (copper, phosphorus, iron, magnesium, calcium etc.) In India, though groundnut is primarily an oilseed crop, but with the increased domestic production of Rapeseed & Mustard, Soybean, Sunflower and import of cheaper Pamolin oil, there is an increasing trend of groundnut consumption as snack food. Edible groundnut of uniform size usually fetches more prices in domestic market as well as in export trade. This is a welcome shift for our country of one billion population where people are mostly vegetarian but production of pulses are low, to augment proteins in daily diet. Moreover, with the liberalization of agricultural trade, there is an urgent need to address sanitary and phyto-sanitary issues and remove trade barriers. Reducing aflatoxin risk to a safer limit will made Indian groundnut globally competitive which otherwise is liked due to its typical nutty flavour. This approach will, not doubt, benefit resource poor dry land farmers to generate additional income and improve economy. The following facts about aflatoxin contamination in groundnut and measures to prevent it should be practiced methodically to: a) put growers in advantageous position by realizing better price for the quality crop; b) keep consumers away from toxin related health hazards by providing safe-to-eat nuts in their daily diet.

Factors for Aflatoxin Contamination

1. At Soil Level

Native population of *Aspergillus flavus* group of fungi varies from farm to farm depending on soil types and crop rotations. Number of colonies per gram of soil varies from thousand to ten thousands or even more in major production areas. Change in soil-water-nutrient balance during the crop growth period activates these fungi and that leads to contamination. Soil borne diseases

such as stem and collar rots and pod rots are prevalent in many parts are likely to encourage *A. flavus* infection in the field. Soil pests like pod borer, wire worm and termite population induces fungus invasion and toxin production. Mechanical damage to pods during interculturing is also responsible for aflatoxin contamination.

2. At Plant Level

Drought-prone sandy soils in which groundnut is grown year after year are hot spots for aflatoxin contamination. Prolonged drought (3-4 weeks) during seed formation and maturation stages triggers aflatoxin contamination. High atmospheric temperature (300-400C) in conjunction with reduced soil moisture availability at crop maturity results invasion of fungus into the pods. Over maturity of the crop has been identified as the potential factor for aflatoxin contamination. Delayed harvest not only results yield loss but also reduces quality and thereby gross returns.

3. At harvesting and post harvest processing level

Mechanical damage to the pods at the time of threshing and or damage to the testa in the process of decortication are the key factors for aflatoxin contamination. Harvesting of crop immediately after irrigation and consequent high initial pod moisture at the time of processing and storage creates congenial condition for aflatoxin build up in the produce. Inefficient and slow drying process under the humid condition enhances aflatoxin contamination risk greatly. Storage of produce in warm and humid room with a large stack directly on the floor favours rapid multiplication of the fungus and thereby affects even good lots.

Aflatoxin Prevention Strategies:

Pre-Harvest

(A) At the Soil Level

Undertake deep ploughing using blade/disc harrow-invert the soils.Keep the soils exposed to hot sun for 2-3 weeks to capture benefit of soil solarization and reduce soil pests and fungal colonies. Remove stubbles of previous crop/weed flora and keep the field clean. Apply Neem Cake @ 1000 kg/ha or Neem and Castor Cake in combination @ 500 kg each in furrow at the time of sowing. In rainfed production system, adopt skip-row method of planting. Avoid shallow tillage and immediate laddering/leveling of soils. Fields should not be weedy or left with crop residues. Do not apply under-decomposed green manure or crop residues in the field.Continuous sowing along the slope may be avoided in dry lands.

(B) At the Crop Level

Select short/medium duration variety, which can escape end of season drought at maturity. Augment sowing taking rainfall pattern into consideration. Advancement of sowing by a fortnight with a pre-sowing irrigation/ pre-monsoon showers helps in evading adverse effect of end of season drought on yield and quality. Use variety with better seed coat resistance and property of high shelling-where kernels firmly adhering with the inner shell. One prophylactic spray of fungicide to control foliar fungal diseases like rust and leaf spot. Harvest the crop at right maturity (blackening of inside shell layer on opening the pod). Look for maximum pod maturity in a plant and then uproot. Ignore few immature pods in a plant, if any, at the

time of harvest. Over matured pods, which usually remain in the soils due to weak peg strength are the major source of aflatoxin contamination. Do not grow long duration variety which may be exposed to drought due to early ceasasion of rains, coinciding with pod maturity. Avoid delay in sowing on the onset of monsoon. Do not allow rainwater to go waste and capture moisture for the best use of the crop, particularly at the critical growth stages. Avoid using of disease and pest susceptible variety with poor shelling property. Do not allow diseases and insect pests to develop. Avoid delaying harvesting. All the pods may not mature at a time-do not wait for the few immature pods, if any, to mature. Never use those collected pods for direct consumption as usually practiced among farm families. Such pods may support even 1000 ppb aflatoxin as against safe limit of 15-20.

(C) At Harvesting and Post-harvesting Level

Set the blade of the digger at right depth to avoid injury to mature pods. Dry the uprooted plants along with the pod in small heaps up side down. Keep in the field for 6-7 days till the leaf/peg become brittle. Separate out immature pods as well as pods infested with soil pests after manual stripping. While using mechanical thresher-put appropriate sieve according to the pod size of the variety and ensure effective blowing of lightweight pods. Dry well filled, healthy pod thoroughly and bring down pod moisture below 10%. This can be judged by rattling sound of pods on shaking a handful of pods. Use new/ clean gunny bags to store the produce. Produce must be stored in a well-ventilated leak proof room. Store bags on wooden pallet dunnage, maintain 1-meter distance from walls and between stack. Don not apply Kurfi/ spade to harvest groundnut crop. Do not detach the pods immediately after uprooting. While drying along with the pods should not come in contract with the soil. Do not keep immature and damaged pods along with healthy pods. Do not dry diseased/pest infested pods along with healthy pods. While storing the produce, moisture should not exceed 10%. Do not put freshly harvested plants in the hopper for threshing. Old/damaged bags should not be used as these may be infested with pests. Groundnut should not be stored in hot and humid room. Bags should be placed directly on the floor.

(D) At the level of shelling /decortications

At house hold level opening of pod is made manually-by hand. Whereas, large scale shelling is done using decorticator-either manually operated or motor driven. In practice, water is sprayed on the dry pods to reduce split/breakage of kernels. Sun dry the kernel to bring down its moisture level below 7% at the time of bagging for trade. At this moisture level, the testa can be peeled off with slight rubbing. Remove shriveled, discolored and damaged kernels from the lot including the nuts with broken testa by hand picking or electronic sorting machine or a combination of both and then put them in new gunny bags. Do not spray water on dry pods-but adjust the space between blade and the sieve according to pod size to reduce breakagge. Kernel moisture level, in any case, should not exceed 7%. Do not put discolored and damaged kernels along with intact and healthy nuts. Do not keep processed nuts in old gunny bags/plastic bags.

Success Story

By adopting and integrating the above packages, it has been possible to demonstrate

aflatoxin risk free groundnut production (0-15 ppb) through farmers's participatory research at Anantapur district of Andhra Pradesh which is known to be a high risk area for aflatoxin contamination in groundnut.

Soybeans

Soybeans with moisture above 13% in storage risk deterioration due to seed respiration, mould attack, spontaneous heating and reduced seed germination. The fungi most often associated with loss of seed viability in storage are *Alternaria, Aspergillus,* and *Rhizopus* but stored seed may carry infection originally contacted in the field. Soybeans with 14% moisture and maintained at 5-8^{o}C can be stored for over two years without mould damage. However, soybeans kept at 30^{0}C can be invaded by moulds in a few weeks causing severe damage in six months. Several storage fungi invade soybeans during storage are *Aspergillus flavus, A.glacus, A.ochraceous, A.niger, A.fumigatus*. Some of these fungi produce mycotoxins like aflatoxins (*A.flavus*) and achratoxins (*A.ochraceous*). Majority of insect pests attacking soybeans in storage are nonspecific. The insects pests found in storage are Bean bug (*Acanthomia* sp.), Greenstink bug (*Acrosternum hilare*), Weevils (*Callosobruchus* sp.). To overcome these problems the handling and transport of soybeans should be done carefully and the bags filled with soybeans should not be dropped more than 50cm of height. In order to control storage losses in soybeans, metal bins could be used and kept in a cool place at a temperature of 15-20^{o}C at a moisture content of 9-10%. The most suitable packet for long-term storage of soybean is a laminated bag made of cellophane, aluminium and polythene. In these packets, 100% viability of soybean seeds could be retained for about 30 months at room temperature

Rapeseed-mustard

In rapeseed mustard uncleaned seeds having more than 7% moisture deteriorate quickly in bulk storage in conventional storage structures such as earthern pots and tar-painted polythene lined bamboo bin. Seed deterioration becomes evident by way of reduced seed viability, increase in free fatty acids and seed discolouration. Seed discolouration is primarily due to fungi like *Alternaria alternate, A.brassicae, A.brassicicola* and *Penicillium citrinum*. Fungi like *Aspergillus candidus, A.flavus, A.niger, Penicillium verrucosum* and *Rhizopus* sp cause increase in free fatty acid content. Rain falling on a standing crop prior to harvesting causes an increase in fungal attack and after harvest the activity of moulds remaining on the seed and residues can cause heating problem in storage. The most important insect pests in storage of rapeseed-mustard are the grain beetle (O*ryzaephilus mercator*) and the red rust flour beetle (*Tribolium castaneum*). Metal bins are more useful in maintaining the keeping quality of rapeseed-mustard seed for up to 4 months of storage at 7% seed moisture content

Sunflower

It is unsafe to store sunflower seeds with a moisture content exceeding 9.5%; more than 11% moisture in the sunflower seeds leads to rapid heating termed as "bin-burning" due to growth of fungal flora. Predominant microorganisms on the surface of sunflower seed after longer storage

periods are reported to be facultative anaerobic yeast fungi rather than usually occurring fungi and bacteria. Sunflower seed with increased phytomelan layer and low oil content is less susceptible to insect damage in store. The most common cosmopolitan storage pests include Coffee bean weevil (*Araecerus fasciculatus*), Almond ware house/ tobacco moth (*Ephestia cautella*), Indian meal moth (*Plodia interpunctella*), Granary weevils (*Sitophilus* spp), Rust flour beetle (*Tribolium castaneum*), Grain mites (*Tyroglyphus* sp), Rodents have been found to be causing serious damage to sunflower seed in mud-bins.

Safflower

Safflower seeds can be stored well at 8% grain moisture content without any tangible loss of viability, but stringent environment control is necessary for safe and long term storage. Grain bins are useful for storing safflower seeds in bulk when moisture content of the seed is around 5%. Significant increase in free fatty acid content has been reported in all the storage structures due to storage fungi but maximum effect on free fatty acids has been reported in seeds stored in earthen pitchers and plastic containers. Insect pests like *Lasioderma serricorne*, *Trogoderma glabrum* and *T.inclusum* have been commonly reported as storage pests of safflower. Thin-hulled varieties are more susceptible to damage by storage pests than those with thicker hulls.

Sesame

Sesame seeds can be stored in bulk more economically than many other oilseeds because of its small size. However, under high relative humidity and temperature conditions, infections by fungi increase with increase in storage time. The most common storage pests of sesame are *Tribolium castenium, Ephestia cautella, Trogoderma granarium, Corcyra cephalonica.*

Eco-friendly management of stored grain pests of oilseeds:

Researchable issues and strategies

1. Good crop husbandry

Establishment of oilseed crops under receding moisture content, timely weeding, plant protection, life saving irrigation (avoiding drought stress), timely harvesting and threshing to avoid losses in storage are the major issues. Improved implements need to be adopted by farmers or made available to farmers for handling of oilseeds

2. Improved post harvest technology

More systematic research needs to be done on harvesting, threshing, storage and handling of different oilseeds under different situations so that location and crop specific technologies could be developed. Linking of farm produce (seed) directly with processers/millers should be explored and can be a part of post-harvest technology research.

3. Safe storage moisture content of various oilseeds

The moisture content of oilseeds in storage conditions is very important and it varies from crop to crop as in groundnut pods (7-9%), groundnut kernels (4-6%), rapeseed-mustard (7-9%), soybean (5-10%), sesame (5-8%), safflower (4-6%), sunflower (7-9%), nigerseed (6-8%), linseed (6-8%) and castor (6-8%).

4. Contract Farming

Contract farming may be explore in areas where farmers have large holdings and inputs are not constraints to produce export quality groundnut by providing them with technical expertise and good seeds on a contractual basis. Production of such seeds can be used for export and for cultivation in larger areas. Storage of oilseeds using inert gas technology (Nitrogen) need to be developed. A combination of sealed storage and aeration can be proved to be a very effective system for long term storage of oilseeds Top priority research strategy to search host plant resistance and development of crop varieties producing seeds possessing resistant/tolerance to storage fungi and insects be formulated. Intensified studies on population dynamics and colonization pattern of storage fungi and insect pests need to be done. Role of biocontrol agents with particular reference to storage fungi and insect pests has not been well studied yet. Hence research activities need to be strengthned in this field. Such project activities should also include cross-protection studies with special reference to storage fungi like *Aspergillus flavus.* Use of botanicals as alternatives to pesticides (fumigant/seed treatment insecticides/fungicides) need to be tested through a planned systematic research project. There has been increase in number of such plant based formulations (for example neem, paras tikki) in the market and these should be examined against stored grain pests/ storage fungi of oilseeds for practicable application technology. Traits related to storage and shelf life, and harvested products of oilseeds can be endowed with better characteristics such as oil quantity and quality, protein quality and other nutrients by using genetic engineering techniques. Genetically modified rapeseed-mustard plants for pod shatter resistance and also that of groundnut pod for resistance to soil borne fungi could be quite useful to reduce the harvest and post harvest losses. Research on understanding the **biosynthetic pathway for aflatoxin** production should be intensified. For example, Lipoxygenase (Lox gene) enzymes and their products (C_6-C_{12}) are known to inhibit aflatoxin biosynthesis. Some of the cloned genes (Lox) of aflatoxin biosynthesis pathway can be effectively utilized to induce resistance to aflatoxin production. Thus there is a possibility of development of transgenic groundnut with resistance to aflatoxin production. New such projects need to be taken in hand for future improvement of protection of losses of oilseeds in storage due to fungi and insect pests and produce export quality oilseeds.

Weed Management in Relation to Plant, Human and Environmental Health

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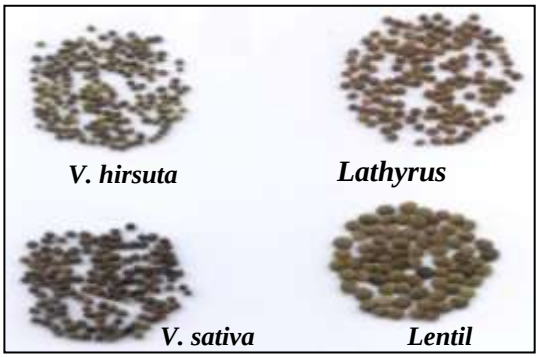
A weed is a plant growing where it is not required. Jethrodull in 1731 first time used the term weed for unwanted plants in his book horse hoeing husbandry. Weeds are unwanted and undesirable plants which interfere with the utilization of land and water resources and thus adversely affect human welfare. It reduces the quality as well as quantity of the crop produce and land value. These undesirable plants survive from year to year and have ability to compete with an advantage over most agriculture crops. Some weeds mature little earlier than or along with the crops associated and thus their separation becomes difficult during harvest and remains admixture with crop seeds and perpetuate year after year this is known as chornological mimicry.e.g. *Cichorium intybus* matures with *berseem, phalaris minor*/paradoxa and *avena fatual ludoviciana* with wheat, barley and cultivated oat. Some of the weeds produce seeds similar in shape, size and weight as that of some crop seeds called "satellite weeds" and this attribute /phenomenon of weeds is called "seed mimicry". Economic loss in Indian agriculture is about 2000 crores due to pest out of which maximum is due to weeds infestation i.e. 45% and annual loss of weeds in Indian agriculture is about Rs.1980 which is more than the combined losses caused by insect pest and diseases (Fig 1).



Similar size, shape and color of the weed seeds as pulses

Similar size, shape and color of the weed seeds as rice and toria seeds

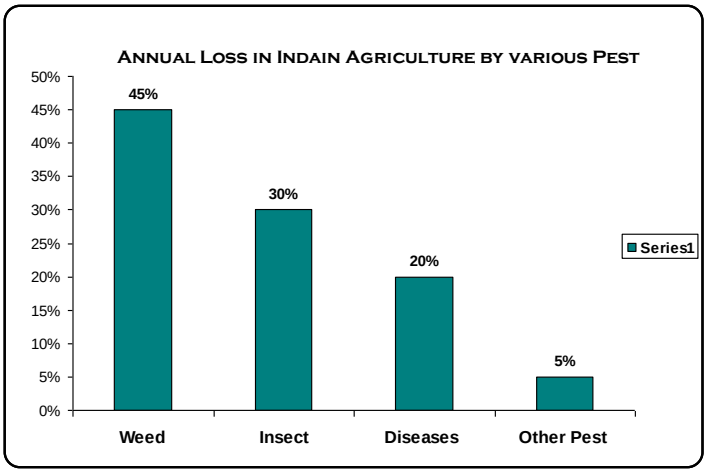


Fig 1: Economic loss about 2000 crores in Indian agriculture due to pest

Weed menace to Agriculture: Weed and the treatments (herbicides etc) used to control the weeds reduces the crop quality, crop yield as well as production efficiency of the crop. The crop quality is reduced by the contamination of food

grains with admixiture of weed seeds and some of the weeds are poisonous in nature which fetches low prices e.g. presence of loranthus (*Dendrophthloe falcata*) in tea impair its quality, *Cirsium arvense* a common weed of mint plantations is often crushed with mint leaves and thus lowers its oil quality, in certain pulses and legume ,oilseed crops herbicidal control of weeds has been reported to simultaneously influenced the nodulation in plains. Weeds causes loss in crop yield by growing with crop plants and causes tremendous reduction in its yield it is about 30.6-69.4 % in case of cereals, 37.4-49.5% in pulses and 33.5-38.8% in oilseeds (fig.2). Weeds may also create some indirect trouble in field such as at the time of field preparation, fertilizer application, harvesting etc. One important way the weeds spread on the farmlands is through contaminated with the weeds seeds. Dunga and Bolin1950 has discovered a score card for judging the quality of common crop seeds contaminated with weed seeds. This card shows that the bigger crop seeds like maize, cotton carry less weeds with them as compared small seeded crop. The crop seed judging score card show highest weightage for weed contamination in the case of legume forage grasses and small grains.

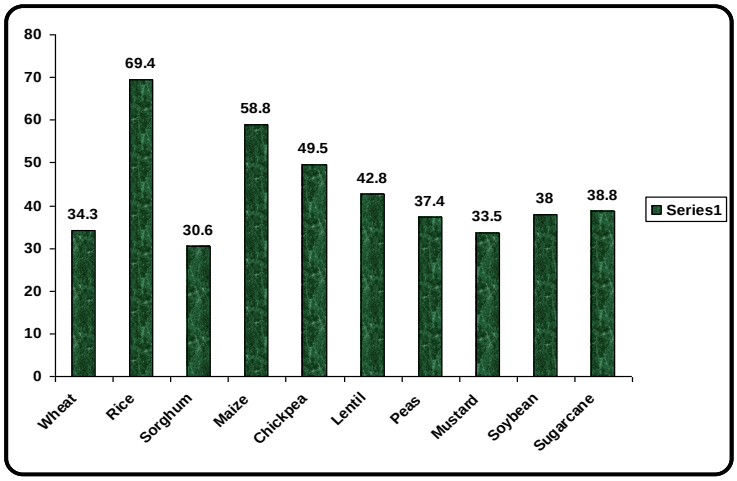


Fig 2. In economic terms the weeds cause an annual loss Rs. 1980 crores to Indian agriculture which is more than the combined losses caused by insect pests and disease

Table1: Weightage to weed seed contamination allotted in score card for judging Quality of common crop seeds (Dungan & Bolin, 1950)

Crop	% marks	Crop	% marks
Barley	35	Maize	0
Cotton	0	Oat	35
Cowpea	30	Potato	0
Forage grasses	45	Soybean	10
Forage legumes	55	Sorghum	25
Linseed	12	Wheat	35

It is very important to have a hard look into the seed drill boxes and seed bags before planting. An apparently small weed content of, say 1% in wheat, will plant 1 kg weed seeds per ha. With usually very low test weights of weed seeds, this quantity of weed seeds is sufficient to infest the land with additional few thousand of seed plants. And when the contaminant in crop seed is a noxious weed, the presence of even a single weed seed in the drill seed is enough to start an

unmanageable weed infestation on the farm. It is therefore, highly undesirable to plant new areas with crop seeds carrying any noxious weed seeds. (Table 2)

Table 2: Weed species Designated as objectionable according to seed Act 1966 (of India) and their maximum permissible limits in certified seeds Against the total weed seed permissible limits in certain crops

Crop	Objectionable weed*	Permissible seed admixture limits	
		Objectionable weed	Total Weed
Paddy (*oryza satva*)	Wildrice or redrice (*O. sativa Var fatua*)	0.02%(5)	(20)
Wheat (*Triticum aestivum*)	(Convovulus arvensis & P. minor)	0.01% (5)	(20)
Rape and Mustard (*Brassica campestris* and *B. juncea*)	Mexican popy (Argemone mexican)	0.1 % (10)	(20)
Egytianclover (*Trifolium alaexandrinum*)	Chicory (Chichorium intybus)	0.05% (10)	(20)
Lucerne (*Medicago sativa*)	Dodder (Cuscuta spp.)	0.05% (10)	(20)
Methi (Fenugreek) (*Trigonella foenum-graceum*)	Senji (Melilotus)	0.2%(5)	(20)
Lettuce (*Lectuca sativa*)	Wild lettuce (Lectuca serriola)	0.2%(5)	(10)
Cucurbit (*Cucurbita spp*)	Wild cucurbit (cucurbita spp.)	0.0(0)	(0)
Okra (*Abelmischus esculentus*)	Wild okra (Abelmoschus spp.)	0.0 (0)	(0)

*A noxious weed whose seeds are difficult to separate when mixed with the crop seeds.

*Figures in % show proportion of weed plants to crop plants by number.

** Figures in brackets show number of weeds seeds per kg crop seeds.

Weeds also require the same nutrient as the crop plants and competes for light and space. The better competing ability of weeds than our crop plants has resulted weeds often accumulate very large quantity of dry matter every season e.g. 20-27 q ha^{-1} dry matter wt (4-6 months). Weed seeds compete with crop plants for different factors such as nutrient, light , space and moisture. Weeds absorb and accumulates mineral nutrients in higher concentrations than the common crop plants. eg- *Amaranthus viridis* accumulate upto 3% N, weeds often have higher requirement than the crop plants. eg- consumptive use of water of *Chenopodium album* was found to be 550 mm against 479 mm of wheat crop, weeds compete with crops for light needed for photo-synthesis by shading the young crop seedlings. Most of the weeds put forth rapid initial growth particularly during the rainy season. The crop seedlings thus become weak and some times, wither away

under the mat of weeds. Weed compete with crops and interfere in harvest operation. Higher cost is incurred towards weed control manually or by herbicides . The cost of harvesting crop both by manual and mechanical methods may also increase due to weed infestation. All these ultimately increase the cost of time of operation and crop production.

Weed menance to health:

Heath, comfort and work eficiency of man are adversely affected by weeds. Numerous people are plagued year after year with hay fever and asthma aggravated by pollens of *Ambrosia arthumissifolia.* Weeds provide food, protection and habitat for the reproduction of vectors of fatal human diseases. A*quatic weeds* like waterlettuce (*Pistia lanceolatate)*, allgatorweed (*Alternanthera spp)*. Shelter the alternate hosts and vectors of malaria, yellow fever, encephalitis, dangue fever and filariasis. Then there are weeds which cause direct food poisoning. Wheat flour contaminated with the seeds of corncockle (A grostemma githago) gives breade a bitter taste and irritates the gastic tract of the consumer.

Parthenium hysterophorus (Asteraceae) commonly known as Carrot Weed, Gajar Ghas, Chatak Chandani was first reported in India 1951 in Maharashtra. It is native to Mexico including West Indies and Central South America. It causes large number of health hazards as it contain sesquiterpene lactones which induce several allergic reactions in susceptible individuals who are continuously exposed. Itching, eruptions develop on exposed parts of the body, particularly the upper eyelids, sides of the neck, parts of the body, v of the neck, fronts of elbows and back of the knees. Parthenium is also the greatest source of dermatitis, asthma, nasal-dermal and nasal-bronchial types of diseases**.**

Weeds Menace to Aquatic system

Not only land, weeds are a nuisance also in land and water bodies.Aquatic weeds make their appearance repulsive and Decline their recreational values. Water flow in irrigation channels is slowed. The potable and driking water bodies are fouled by the presence of decomposing aquatic weeds (Gupta 2001).

Weed menace in Industry & Public Utilities

Weeds growing on industrial sites and air fields are potential source of fire hazards, eg *lantana camara*. Some weeds penetrate through even asphaltic surfaces which get weakened. Weeds also weaken the railway tracts and airstrips.

Impact of weeds on Environment:

Weeds are one of the major threats to the natural environment. They are destroying native habitats, threatening native plants and animals and choking our natural systems including rivers and forests.

Weeds are one of the major threats to Australia's natural environment. Major weed invasions change the natural diversity and balance of ecological communities. These changes threaten the survival of many plants and animals because the weeds compete with native plants for space, nutrients and sunlight.

Alien Weed Species

Species that have become able to survive and reproduce outside the habitats where they evolved or spread naturally are known as alien species.Alien species becomes established in natural or semi-natural ecosystems or habitat, an agent of change and threatens native biological diversity. The accidental introduction of invasive alien species occurs through travel or imports such as food grains and wood.

Table 2: Introduced weeds and their probable origin:

Weed Species	Probable origin
Alternanthera spp	South America
Convolvulus arvensis	Eurasia
Cirsium arvense	Europe, North Africa & Easter Asia
Cyperus rotundus	Euraisa
Centaurea repens	New East
Eupatorium odoratum	West Inides and Tropical America
Euphorbia hirta	Europe
Eichhornia crassipes	Tropical America, Brazil
Hologeton glomeratus	Western Asia
Lantana camara	Central America/Tropical America
Opuntia spp.	Western hemispher/South America
Parthenium hysterophorus	Tropical America
Mikania micrantha	Neotropical origin
Ageratum conyzoides	South America

These alien weeds mainly leads to loss in biodiversity, change in hydrology & ecosystem function, change in soil structure, its profile, decomposition, nutrient content of soil, moisture availability etc. Weedy rice competes with cultivated rice and reduces crop yield. Farmers cannot harvest the grain of weedy rice as it tends to mature earlier and to shatter readily. Weedy rice in a harvest crop can reduce the market value because of contamination with red grain. Manual weeding is effective for reducing initial infestations of weedy rice, Removal of weedy rice plants when the weeds first infests a field can help prevent more serious infestations in future crops.

Management of weeds:

The main aim of weed management is to achieve reasonable good control of weed. Common methods adopted for weed control are Prevention, Eradication and Control. In preventative measures for controlling of weeds we should use clean seeds and well rotten FYM, Weeds should be uprooted before flowering, irrigation channels and field boundaries should free from weeds. Removing the weeds physically or with tools /implements is called mechanical weed control method. Different mechanical methods adopted for controlling weeds are tillage, hand

pulling, hand hoeing, interculture, flooding, and flaming and steaming. The cultural practices use to control the weed population are crop rotation , date of sowing, plant density, planting pattern / crop architecture, method of fertilizer application, selection of quick growing varieties, mulching, soil solarization.

Quality Control Acts

The Prevention of Food Adulteration Act was started in 1954 and the PFA rules were established in 1955, as amended. The main aim of this act was to protect India from impure, unsafe and fraudulently labeled foods. The fruit and vegetable processing sector is regulated by the Fruit Products Order 1955 which is administered by the department of food processing industries. The FPO contains specifications and quality control requirements the production and marketing of processed fruit and vegetable, sweetened aerated, water vinegar, synthetic syrups. All such processing units are required to optain a license under the FPO. The Export (Quality control and inspection) Act was started in 1963. The export inspection council is responsible for the operation of this act. Under this act, a large number of exportable commodities and organizations may be recognized as agencies for inception and quality control. Recently, the government has exempted agriculture and food & fruit products, fish and fishery products for Compulsory pre-Shipment inspection provided that the exporter has firm letter from the overseas buyer stating. The Insecticide Act (1968) envisages safe use of insecticide so as to ensure that the leftover chemical residues do not pose any health hazards. Export (quality control and inspection) Act 1963 has aims to facilitating export trade through quality control and inspection before the products are sold to international buyers. Environment protection act, 1986 this act Incorporates rules for the manufactured, Use, import and storage of hazardous microorganisms/Substance/ Cells used as food stuff.

There are two organizations that deal with voluntary standardization and certification in the food sector. The Bureau of Indian Standards looks after Standardization of processed foods and Standardization of raw agricultural produce is under the purview of the directorate of marketing and inspection. India introduced the plant Quarantine Order in 2003 to prohibit and regulate the import of the agricultural articles. Orders include A ban of the important certain plants and planting materials from designated countries (e.g. Sugarcane from Australia) A restriction on the import of other plants and plant materials authorized institutions, with additional declarations and special conditions attached .

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Eco-Friendly Management of Diseases for Safe Storage and Export of Maize

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Althought there is a record of a great number of fungi being present on or in maize seed in India, but those involved in the causation of diseases are not many Three types of fungi may be distinguished: (!), fungi involved in inciting diseases such as seed rots, seedlings blights, foliar diseases, downy mildews, stalk rots and wilts, cob and kernel rots: (2), fungi involved in deteroration during storage and (3), fungi producing myxotoxins in association with maize kernels.

Table 1 summarises the available Information and pertaining to bacterial pathogens of maize has also been included.

As will be evident that certain fungi are listed in all the three columns showing thereby that they have been implicated in each of the three categories listed above.

The incidence of, or infestation by, a majority of these fungi can be kept in check by procedures which are not too difficult to adopt. The primary determinant involved in the problems is the seed moisture on and after harvest and after shelling.

The fungi associated with seed rots, seedling blights and certain foliar diseases are easily eliminated by resorting to treatment of seed meant for planting by fungicides such as Thiram or Captan.

Some foliar diseases, such as the one caused by race t of Helminthosporium maydis is also known to infect the kernels. The disease is presently restricted to certain areas of Punjab and therefore one experimental hybrid EH 2420 was not recommended for release because of its showing susceptibility in that State.

In respect ot downy mildews, three options are available : (1) sun-drying of the shelled grain (2) keeping the moisture level of the grain under 20 per cent and (3) storage of the harvested and shelled grain at least for a period of four months before planting. In addition, currently a systemic fungicide-Metalaxyl appear to be promising for controlling this group of pathogens.

As far as storage moulds and those involved in producing mycotoxins are concerned the best in storage recommendation is to have seed in such a way that the moisture level of the grain is 13% or less. Moulds belonging to species of Aspergillus or Penicillium are prevented from becoming active and from doing damage by resorting to this practice.

Table 1: Seed –associated fungi involved in causing disease (Column 1). Deterioration (Column 2) and in production of mycotoxins (Column 3) in maize

Fungal Pathogens	(1)	(2)	(3)
Seedrots, seedling blights	*Cephalosporium acremonium, Fusarium moniliforme, Rhizoctonia spp., Aspergillus niger Sclerotium rolfsil Penicillium oxalicum*	*Aspergillus amstelodamii A. carbonarius A. flavus A. niger and A. ruber*	*Aspergillus flavus, A. niger, Fusarium moniliforme Botryodiplodia theobromae*

Foliar diseases	*Helminthosporium maydis RaceT,*		
Downy mildews	*Peronosclerospora philippinensis* *P. sacchari* *P. Sorghi*	*Chaetomium globosum* *Fusarium moniliforme*	*Maorophomina phaseolina*

Stalk rots and wilts	*Fusarium graminearum, F.moniliforme, C. acremonium,* *C. maydis*	*Penicillium citrinum*	
Cob, ear and kernel rots	*Rhizoctonia zeae, Fusarium graminearum,* *F. moniliforme, Nigrospora, oryzae, Diplodis maydis, D. macrospore, Aspergillus niger, Macrophomina phaseolina, Botryodiplodia theobromae*	*P. funiculosum* *P. oxalicum*	*Penicillium Funiculosum*
BACTERIAL PATHOGENS			
	Pseudomonas lapsa (Stalk Rot) *P. rubrilineans (Leaf Stripe)*		

Table 2: Important disease of maize in different maize growing regions of India

Region	Disease	Causal organism	Sources of resistance
Himalayan Region	Turcicum leaf blight	*Exserohilum turcicum*	CM 103, 104, CM 105, Eto 25, Eto 81-B, Ph DMR 1, Ph DMR 5
	Leaf and sheath blight	*Rhizoctonia solani f. sp. sasaki*	CM 104, CM 105, CM 300
	Brown spot	*Physoderma maydis*	CM 106, CM 108, SS II, CE 440, Cuzco, CM 300
	Common rust	*Puccinia sorghi*	CM 103, CM 104, CN 105, CM 106, CM 113, Cuzco
	Bacterial stalk rot	*Pythium aphanidermatum*	CM 104, CM 600
	Pythium stalk rot	*Helminthosporium maydis*	CM 110, CM 300, CM400, CM 600
North-Western Plains	Maydis leaf blight	*Helminthosporium maydis*	CM 103, CM 104, CM 05, CM 106, CM 111, CM 113, CM 201, Ento's

Table 1 contd.

Region	Disease	Causal organism	Source of resistance
North-Eastern Plains	Brown stripe downy mildew	*Sclerophthora rayssiae var. zeae*	CM 104, CM 105, CM 500

	Baterial stalk rot	*Erwinia chrysanthemi corn pathotype*	CM 104, CM 600
	Black bundle disease	*Cephalosporium acremonium*	CM 103, CM105, CM 109, CM 300, Eto 25, Eto 28-A
	Charcoal rot	*Macrophomina phaseolina*	CM 103, CM 104, CM 107, CM 111, CM 112, CM 202, CM 300, CM 600
	Late wilt	*C. maydis*	CM 111, CM 202, CM 300, CM400
	Common rust	*Puccinia sorghi*	CM 103, CM 104, CM 105, CM 106, CM 113, Cuzco
	Maydis leaf blight	*As above*	As above
	Brown stripe downy mildew	*As above*	As above

Region	**Disease**	**Causal organism**	**Sources of resistance**
North – Western Plains	Bacterial stalk rot	As above	As above
	Black bundle diseases	As above	As above
	Charcoal rot	As above	As above
	Late wilt	As above	As above
	Common rust	As above	As above
Peninsular India	Turcicum leaf blight	As above	As above
	Common rust	As above	As above
	Downy mildew	Peronosclerospora sorghi	Tx 601, Ph DMR 9, CM 106, Ph DMR 1, Ph DMR 5, MDR I and MDR II
	Black bundle	As above	As above

Table 3 : Materials showing resistance to more than one disease

Pedigree	Diseases
CM 104	Brown stripe downy mildew, turcicum and maydis leaf blights, rust, leaf and sheath blight, bacterial stalk rot, charcoal rot
CM 105	Brown stripe downy mildew, turcicum and maydis leaf blights, rust, leaf and sheath blight, black bundle disease
KNR 35	Turcicum and maydis leaf blights, diplodia stalk rot
CM 106	Sorghtum down mildew, turcicum and maydis leaf blights
CM 500	Brown stripe downy mildew, Botryodiplodia stalk rot, maydis leaf blight
CM 600	Bacterial stalk rot, pythium stalk rot and charcoal rot
Phil. DMR 1 Phil. DMR 5	) Downy mildew, common rust) turcicum and maydis leaf blight
MDR 1	) Multiple disease resistant stocks)

Maize (*Zea mays L.*) is versatile crop grown in more than 160 countries in tropical, sub tropical and temperate regions from sea level to > 3000 masl, In India, maize is the third most important cereal after rice and wheat that provides food, feed, fodder, and serves as source of raw material for developing hundreds of industrial products viz., starch, protein, oil, alcoholic beverages, food sweeteners, pharma, cosmetics, bio-fuel, etc,

In India as per the latest report maize area production and productivity is 8.17 mha, 19.73 mt and > 2.4 t/ha, respectively. The maize production has increased > 12 times from a mere 1.73 mt (1950-51) to 19.73 mt (2008-09). The demand for maize will touch 42 mt by 2025, of which 20-21% will be used for human consumption, >60% as poultry and livestock feed and the remaining 12-13% for industrial raw material. These figures would remain constant for another 10-15 years.

Witnessed 30 % increase in production and 27% are under SCH. There is also 15% annual increase in production and > 12% increase in productivity. India became net importer to exporter. India exported 3 mt in 2007- 08 and 2.8 mt in 2008-09 to nearby countries. This is a visible impact of SCH. The planning commission on agriculture has set the growth rate target of 4 % and the required growth rate is 4.7% but we are much ahead of the demand and production.

All India Area, Production and Yield of Maize from 1950-51 TO 2008-09

Year	Area	Production	Yield
1950-51	3.16	1.73	547
2003-04	17.32	14.98	2039
2004-05	7.43	14.14	1887
2005-06	7.59	14.17	1938
2006-07	7.89	15.09	1912
2007-08	8.12	18.96	2335
2008-09	8.17	19.73	2415

Advances in Electron Microscopy and application in Plant Pathology

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Introduction

One of the most important tasks in the education of a pathologist is learning to distinguish normal from abnormal tissues. Typically, training programs provide an adequate background for the examination and interpretation of tissues at the gross and light microscopic (lm) levels, leaving the student pathologist to his/her own devices to develop necessary skills at the ultrastructural level. The purpose of this presentation is to facilitate development of these skills in ultrastructural examination/interpretation of tissues, by providing a starting point, some tools for study, direction, and finally, a goal at which to aim. Since it would be unrealistic to attempt to go into depth in the short time allotted, the presentation will concentrate on an approach to interpretation of ultrastructural cases while providing a broad overview of some commonly examined tissues.

A human eye can distinguish two points 0.2mm apart. Man's quest to see the unseen and beyond what can be seen with the naked eye led to the discovery of simple magnifying glass that produces an enlarged image of an object. Further improvement led to development of light microscopes that use a combination of magnifying glasses/lenses. Dr.Ernst Ruska at the University of Berlin built the first Electron Microscope (a Transmission Electron Microscope) in 1931 and could get a resolution of 100nm using two magnetic lenses. Today using 5-7 magnetic lenses in the imaging system a resolution of 0.2nm can be achieved. The introduction of the electron microscope as a tool for the biologist brought about a complete reappraisal of the micro-anatomy of biological tissues, organisms and cells. In the early days of its application to biological materials, it was the tool of anatomists and histologists, and many previously unimagined structures in cells were revealed. More recent developments in biological specimen preparation have come from biochemists and physicists who have used the electron microscope to examine cells and tissue in many different ways.

The two most common types of electron microscopes available commercially are the **TRANSMISSION ELECTRON MICROSCOPE (TEM)** and the **SCANNING ELECTRON MICROSCOPE (SEM)**. In the SEM, the specimen is scanned with a focused beam of electrons

which produce "secondary" electrons as the beam hits the specimen. These are detected and converted into an image on a television screen, and a three-dimensional image of the surface of the specimen is produced. Specimens in the TEM are examined by passing the electron beam through them, revealing more information of the internal structure of specimens.

The Transmission Electron Microscope (TEM)

The TEM is an evacuated metal cylinder (the column) about 1 to 2 meters high with the source of illumination, a tungsten filament (the cathode), at the top. If the filament is heated and a high voltage (the accelerating voltage) of between 40,000 to 100,000 volts is passed between it and the anode, the filament will emit electrons. These negatively charged electrons are accelerated to an anode (positive charge) placed just below the filament, some of which pass through a tiny hole in the anode, to form an electron beam which passes down the column. The speed at which they are accelerated to the anode depends on the amount of accelerating voltage present.

Electro-magnets, placed at intervals down the column, focus the electrons, mimicking the glass lenses on the light microscope. The double condenser lenses focus the electron beam onto the specimen which is clamped into the removable specimen stage, usually on a specimen grid.

As the electron beam passes through the specimen, some electrons are scattered whilst the remainder are focused by the objective lens either onto a phosphorescent screen or photographic film to form an image. Unfocussed electrons are blocked out by the objective aperture, resulting in an enhancement of the image contrast. The contrast of the image can be increased by reducing the size of this aperture. The remaining lenses on the TEM are the intermediate lens and the projector lens. The intermediate lens is used to control magnification. The projector lens corresponds to the ocular lens of the light microscope and forms a real image on the fluorescent screen at the base of the microscope column.

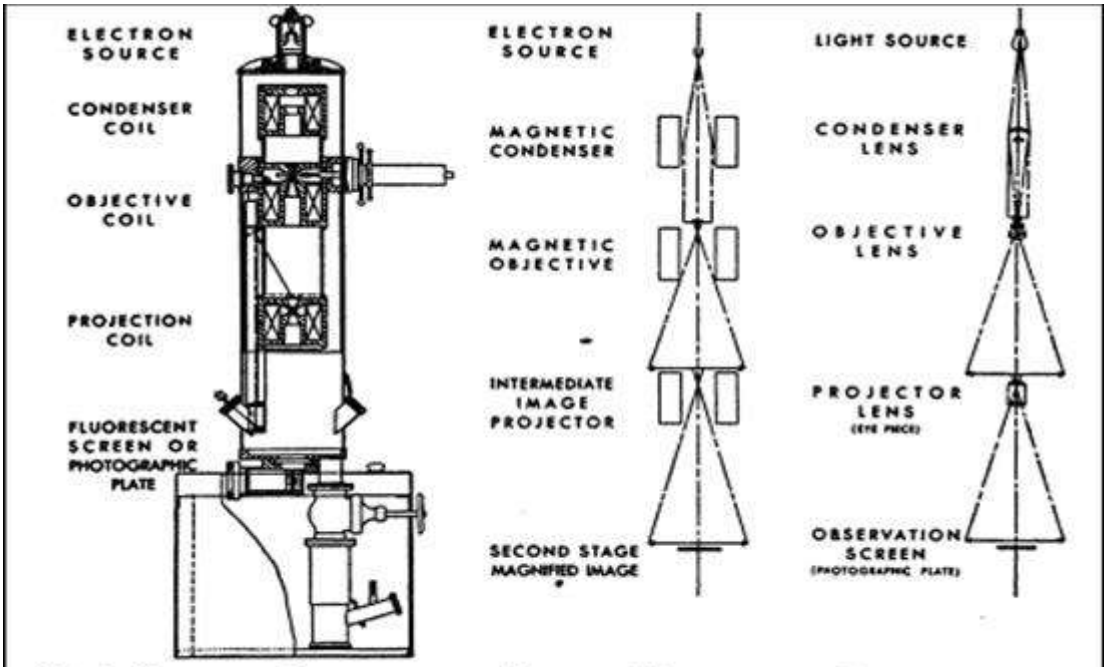


FIG. 1. SCHEMATIC DIGRAAM OF THE ELECTRON MICROSCOPE IN COMPARISON WITH THE LIGHT MICROSCOPE

Resolving Power

The human eye can recognize two objects if they are 0.2mm apart at a normal viewing distance of 25 cm. This ability to optically separate two objects is called resolving power. Any finer detail than this can be resolved by the eye only if the object is enlarged. This enlargement can be achieved by the use of optical instruments such as hand lenses, compound light microscopes and electron microscopes.

Resolution in the light microscope

In the light microscope, the quality of the objective lens plays a major role in determining the resolving power of the apparatus. The ability to make fine structural detail distinct is expressed in terms of numerical aperture (NA). The numerical aperture can be expressed as $n \sin\alpha$ where n is the refractive index for the medium through which the light passes (n air =1.00; n water = 1.33; n oil = 1.4), and α is the angle of one half of the angular aperture of the lens. Light microscope objective and condenser lenses are usually designated by this NA value.

In a light microscope, a beam of light is directed through a thin object and a combination of glass lenses provide an image, which can be viewed by our eyes through an eye piece. The image formed is realistic, because it uses visible multicolor light. Visible light has wave like nature with a wavelength (λ) of 400-800 nm. Since the resolution cannot be less than half the wavelength (λ), the ultimate resolution attainable by using the light microscope is 200nm. This corresponds to a magnification of 1000 times as compared to an eye. Any magnification higher than this will not resolve more detail but will only give “empty magnification”.

(1mm = 1000 µm; 1 µm = 1000nm; 1nm = 10 A^0)

Changes in resolution with wavelength (light microscope)

Light source	Green	Blue	Ultraviolet
Wavelength (nm)	546	436	365
Resolution (nm)	190	160	130

Resolution improves with shorter wavelengths of light

It can be seen from the above table that resolving power improves as the wavelength of the illuminating light decreases. To explain this more fully, the resolving power of the optical system can be expressed as

$$R = \frac{\lambda}{2\,NA}$$

where

- R is the distance between distinguishable points (in nm),
- λ is the wavelength of the illumination source (in nm),
- NA is the numerical aperture of the objective lens.

The optimal resolving power for a light microscope is obtained with ultraviolet illumination (λ = 365) if a system with the optimal NA is used (1.4).

In this example

$$R = \frac{365}{2 \times 1.4}$$

R = 130.4 nm

In the visible region of the spectrum, blue light has the next shortest wavelength, then green and finally red. If white light is used for illumination then the applicable wavelength is that for green. This is in the middle range of the visible spectrum and the region of highest visible sharpness.

Improvement of resolving power

Due to this limitation of resolving power by light microscopy, other sources of illumination, with shorter wavelengths than visible light, have been investigated. Early experiments using X-rays of extremely short wavelength were not pursued further because of the inability to focus these rays. The first breakthrough in the development of the electron microscope came when Louis de Broglie advanced his theory that the electron had a dual nature, with characteristics of a particle or a wave. The demonstration, in 1923 by Busch, that a beam of electrons could be focused by magnetic or electric fields opened the way for the development of the first electron microscope, in 1932, by Knoll and Ruska. Although the initial development of the electron microscope, in Germany, was followed by technical improvements in America, the first commercially available apparatus was marketed by Seimens.

Specimen preparation for TEM

The greatest obstacle to examining biological material with the electron microscope is the unphysiological conditions to which specimens must be exposed.

Since the material must be exposed to a very high vacuum (10^{-5} to 10^{-8} Torr) when being examined, it must be dried at some stage in its preparation. The biological specimen must be stabilized (or fixed) so that its ultrastructure is as close to that in the living material when exposed to the vacuum.

The limited penetrating power of electrons means that the specimens must be very thin or must be sliced into thin sections (50 - 100 nm) to allow electrons to pass through.

Contrast in the TEM depends on the atomic number of the atoms in the specimen; the higher the atomic number, the more electrons are scattered and the greater the contrast. Biological molecules are composed of atoms of very low atomic number (carbon, hydrogen, nitrogen, phosphorus and sulphur). Thin sections of biological material are made visible by selective staining. This is achieved by exposure to salts of heavy metals such as uranium, lead and osmium, which are electron opaque.

Fixatives are used to prevent autolysis, change in volume and shape and preserve various chemical constituents of the cell.

Aims of Fixation

- To preserve the structure of cells and tissues with minimum or least alteration from the living state.
- To protect them against alterations during embedding and sectioning.
- To prepare them for subsequent treatments such as staining and exposure to the electron beam

Commonly used Fixatives

Glutaraldehyde
Paraformaldehyde ⟶ Primary fixative
Acrolein

Karnovsky's Fixative (Glutaraldehyde + Paraformaldehyde)

Osmium tetroxide ⟶ Secondary fixative

Some other compounds are also there which have the ability to partially fix or stain the cellular constituents e.g. Chromium salts, Uranium salts, lead compounds and Phosphotungstic acid (PTA).

Procedure of Fixation and Block Making

Primary fixation

1-2mm sq thick samples + 2.5% glutaraldehyde made in 0.1M sodium phosphate buffer (pH 7.4) | 2-24 hours at 4°C

Washing

Rinse thoroughly with 0.1 M sodium phosphate buffer (pH 7.4) to wash away excess fixative

Secondary fixation

Osmium tetroxide (1% solution) is commonly used, acts as electron dense stain reacts principally with lipids.

Washing

Rinse thoroughly with 0.1 M sodium phosphate buffer (pH 7.4) to wash away excess fixative

Dehydration

Ethanol or Dry acetone is used to completely dehydrate the tissue.

Clearing

Xylene, Toluene or epoxy propane is commonly used.

Infiltration

Infiltration is done by gradually decreasing the concentration of clearing agent and proportionately increasing the concentration of embedding medium.

Infiltration is carried out with liquid resins.

Embedding

Embedding is done in the embedding medium using a gelatin or beam capsule

Polymerization

Keep the specimen at 40-50°C for overnight for better penetration of the resin and then increase the temperature to 60°C for 24-48 hrs so that the resin gets hardened.

Removing the Blocks from the mould

After polymerization the blocks can be easily removed.

ULTRAMICROTOMY

Glass knife is used for cutting ultrathin sections. Ultrathin sections show interference colors while floating on the liquid of the trough. This makes it possible to determine the thickness of the sections.

Gray-60 nm (600A0); optimal for high resolution work.

Silver- 60-90 nm; ideal for most of the purposes.

Gold- 90-150 nm; useful for low magnification and autoradiography.

Purple ,blue,green and yellow- range from 150-320nm; very thick sections and not suitable for transmission microscopy.

He sections are picked on to the grids to be observed in the TEM

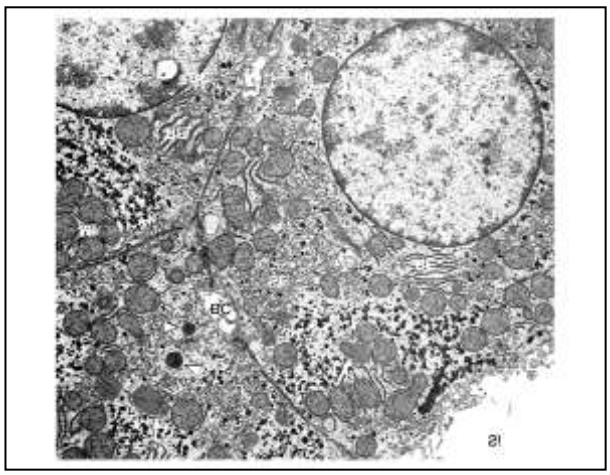
Tem Observations

One of the most important tasks is learning to distinguish normal from abnormal tissues. In order to successfully interpret an electron microscopic (EM) case, you need some of basic tools such as a working knowledge of normal. To describe a micrograph:

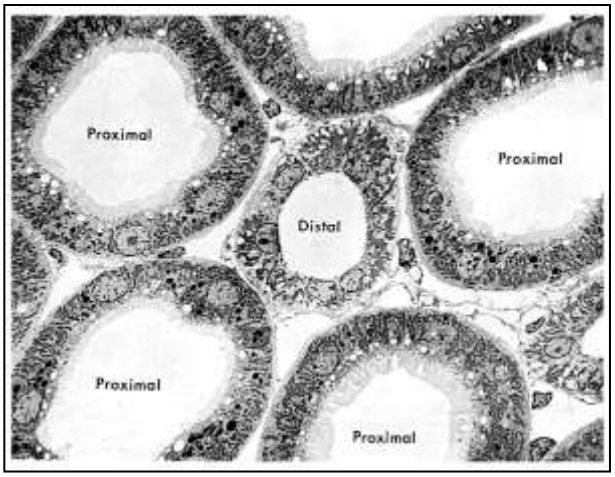
- Begin by stating which tissue(s) is (are) present
- Brief description of normal landmarks present
- Describe pathologic changes
- Have good vocabulary of EM terms - appendix I in the 2nd edition of cell pathology by Cheville has a glossary of EM terms; this is a good starting point.
- *Morphologic diagnosis*
- Same rules apply as for LM cases
- Be concise

Example: hepatocyte: degeneration, diffuse, moderate with intranuclear virions.

Diagnosis must be supported by morphologic description

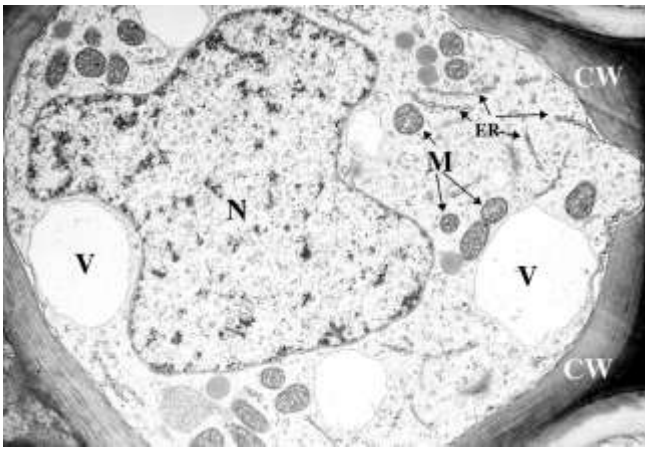


Hepatocyte



PCT Kidney

Below is an EM of a young plant cell: note the nucleus (N) surrounded by a double unit membrane; the cell wall (CW) with its laminated (often amorphous) structure; mitochondria (M) with their internal cristae, the vacuoles surrounded by a single membrane (tonoplast), and the endoplasmic reticulum (ER). The dots throughout are ribosomes.



Nucleus: identified by its size, double unit membrane, and granular texture (due to chromatin).

Cell Wall: identified by its laminated or amorphous texture.

Mitochondria: identified by their size, by their double unit membrane, and by the enfoldings of the inner membrane called cristae.

Plastids: Identified by their double unit membrane.

Leucoplasts can be identified by their absence of cristae or chromatin.Leucoplasts may have amorphous starch grains, or crystalline protein.

Chloroplasts can be identified by their stacks of thallakoid membranes called grana.

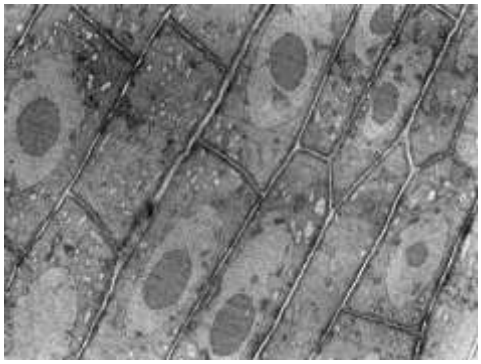
Vacuole - Vacuole membrane: Vacuoles are surrounded by a single unit membrane. The texture inside is clear - evidence of the absence of other cellular components.

Microbodies: Have a single unit membrane and are usually dense in appearance.

Golgi Bodies: In cross section appear as a stack of membrane-bound compartments resembling a cross section of a stack of pancakes.

Endoplasmic Reticulum: Membranes that pervade the cell, seemingly not associated with any of the structures listed above. If ribosomes are clustered along these membranes is called rough ER.

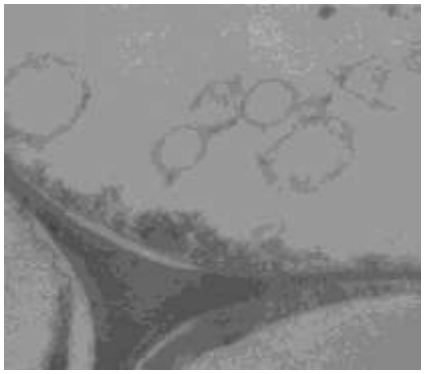
Ribosomes: dot-like structures often associated with endoplasmic reticulum.



Meristematic cells in roots parenchyma from Glycine hispida (10000X)

Chloroplast in Leaf Material

Thicker ascospore walls (TEM) fungus



TEM of phytoplasma colonizing the phloem of an infected stem.

Infectious Agent

A complete treatise of ultrastructural detail of infectious agents is beyond the scope of this presentation. Generally speaking, it is easy to get carried away describing these organisms in any detail, especially protozoa. It is better to describe the essentials, interpret and continue.

Viral

In describing viruses, describe size if a scale marker is present, shape, encapsulated or not, appearance of nucleoid, and where virus is present (intranuclear, budding from cell membranes/ walls, within er, extracellular, etc.).Some viruses are more easily identified ultrastructurally than others:

Poxviruses- relatively large viruses (200-300 nm), replication in the cytosol unlike most DNA viruses, substantial capsule and dumbbell-shaped nucleoid.

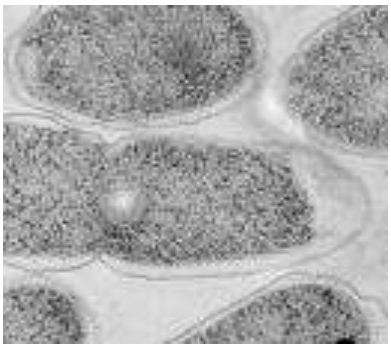
Adenoviruses- characteristic intranuclear paracrystalline array.

Herpesviruses- replication in nucleus where immature nucleocapsids are present, envelope by budding through a membrane (often nuclear, sometimes er or plasma membrane).

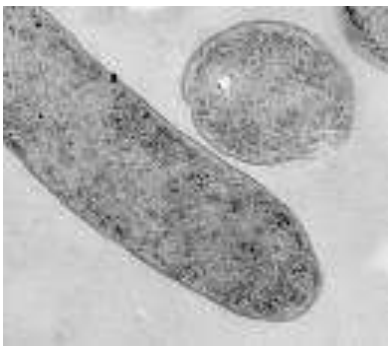
Bacterial

Be familiar with general ultrastructural morphology of a bacterium. Knowing the species of plant / animal, the tissue involved, and occasionally some other features, you can make an

educated guess as to the bacteria with which you are dealing. Describe size if a scale is given, shape (coccus, rod, pleomorphic) and where bacteria are located (i.e. At microvillar tips, closely-adhered to cell membrane / wall, intracytoplasmic and if so, within phagolysosome or free).



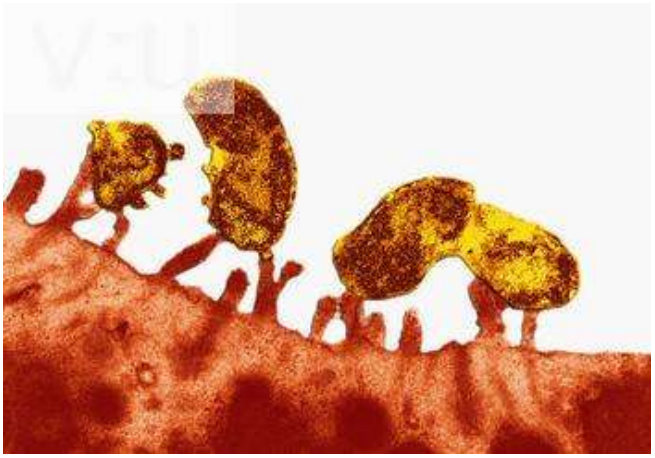
Pseudomonas putida under solute stress



Pseudomonas putida with no stress

Examples:

Bordetella- bacteria enmeshed in tracheal cilia; animal affected may be dog, turkey, etc.Car bacillus- bacteria enmeshed in cilia of airway, but more likely in a rat.



These Helicobacter pylori Bacteria (formerly named Campylobacter) on human stomach epithelial cells can cause certain types of stomach ulcers and gastritis. Peptic ulcers are holes or sores in the stomach or duodenum and most are caused by this pathogen. With antibiotics, the infection can be cured in a few weeks. TEM X40,000

Protozoal

Be familiar with some of the terminology used in describing protozoa, such as conoid, micronemes and rhoptries. Note whether zoites are contained within a parasitophorous vacuole or free in the cytoplasm. If in a bradycyst, is wall thick or thin? Some familiar examples include:

Giardia- elongated, attached along microvillar surface

Cryptosporidium- trophozoites attached to apical cell surface by feeder organelle, microvilli are effaced only at the site of attachment. The trophozoites develop into schizonts.

Journals relating to Electron Microscopy

- Journal of Electron Microscopy (Japanese)
- Journal of Electron Microscopy Techniques

- Journal of Microscopy
- Biology of Cell (French)
- Journal of Ultra-structural Pathology
- Scanning Electron Microscopy
- Ultramicroscopy
- Developmental Dynamics
- Anatomical Record
- Journal of Cell Biology
- Tissue and Cell
- Electron Microscopy Reviews
- Journal of Ultra structure and Molecular Structure Research
- Cell and Tissue Research

Role of Plant Parasitic Nematodes in Post Harvest Losses of Field and Horticultural Crops

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An unseen, underground and hidden, enemy pest, which silently spreads from nursery to nursery, and field-to-field, attacking most of the agricultural crops throughout the world is plant parasitic nematode. Plant parasitic nematodes are microscopic roundworms that live in diverse habitats. They live in soil and plant tissues and feed on plants by puncturing and sucking the cell contents with a spear like mouthpart known as a stylet or spear. Spear is one of the important features that distinguish them from other nematode species living in soil.

Nematodes continue to challenge different agricultural crops all around the world. Since early times the major economically important agricultural crops have been plagued by these noxious microscopic organisms that feed on plant roots, buds, stems, crowns, leaves, seeds, rhizome, sucker, seedlings, tubers etc. The damage caused by these nematode pests to a particular plant depends on crop and cultivars, nematode species, level of inoculum in soil and their environment. The most severe damage generally occurs, when high levels of nematode inoculum with susceptible host plants are planted in fields. Such deleterious effect on plant growth results in low crop / oil yield and poor quality. The major crops affected by these noxious pests are, vegetables, fruits, sugar, cotton, oil seed, pulses, tobacco, tea, coffee, cereals, spices, medicinal and aromatic plants

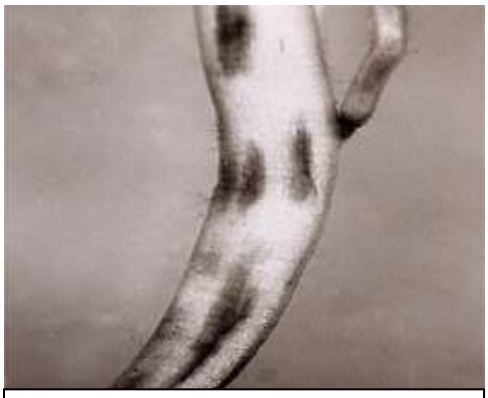
Root galls caused by

The major symptoms caused by plant parasitic nematodes may be observed on shoots and roots. The symptoms described here are indicative of a nematode problem, but are not diagnostic because they could result from other causes as well. Infestations may also occur without causing any aboveground symptoms.

Nematodes that feed on the roots cause above ground symptoms that are similar to those resulting from many kinds of root injury. Foliage loses its luster and wilts. Prolonged root stress caused by nematodes may result in yellowing and eventual loss of foliage. New flushes of growth are stunted and weak, with fewer and smaller leaves than healthy plants. Plants tend to wilt more readily during low water or drought conditions than uninfected plants. The damage is usually distributed irregularly, since nematodes are rarely distributed evenly in the soil. Nematodes that feed on the foliage produce characteristic angled lesions on broad leaves plants. These lesions are very characteristic of a nematode infection. Infections on narrowed leaf plants can be misleading due to the small, strap-like leaves lacking those characteristic angled lesions. Instead the leaves appear randomly to turn

completely brown including patches of yellow on plants, stunting, and poor growth. Less and small fruits, seed galls (ear cockle disease), lesions in leaf (*Aphelenchoides* sp.) are the major symptoms.

Root symptoms caused by nematodes are distributed very widely due to different kind of plant parasitic nematodes. The most common symptoms are: root lesions, root pruning, root galling, and cessation of plant roots. Roots damaged by nematodes can not efficiently use the water moisture and nutrients available in soil. Symptoms of nutrient deficiency such as chlorosis results even where there is an adequate supply of nutrients in planted soil.



Root lesions caused by

Some kinds of nematodes cause damage to tissues on which they feed (root-knot and some foliar nematodes, for instance); some prevent the growth of the roots; others kill the cells on which they feed, leaving patches of dead tissue as they move on. Depending on the kinds of nematodes involved, damage may include galls, stunting, and decay of roots; nematode infested roots are often darker in color than healthy roots. Fungi and bacteria which cause root rots wilt, and other plant diseases often infect nematode-damaged roots earlier and more severely than uninjured roots. Large number plant viruses are transmitted by variety of ectoparasitic nematode species especially species of *Longidorus, Trichodorus, Paratrichodorus and Xiphinema*

Among the different nematode species associated with agricultural crops, only a couple seems to cause most of the serious problems. The root-knot nematodes (*Meloidogyne* spp.) are by far the most important. Their easily recognized galls on the roots make their presence obvious. Galls result from growth of plant tissues around juvenile nematode, which feed near the center of the root. Root-knot gall tissue is firm without a hollow center, and is an integral part of the root; removing a root-knot gall from a root tears root tissue. Nodules formed on roots of many legumes because of beneficial *Rhizobium* spp. (nitrogen-fixing bacteria) and most other natural nodules or bumps are loosely attached to the root and have hollow centers. Active *Rhizobium* nodules have a milky fluid in their centers.

Nematode parasitism in host plant causes mechanical injury and develops complex host parasite relationship. Such interaction involves physiological changes in host tissue resulting from substances secreted by nematodes and perhaps substances produced by the plant in reaction to the presence of the nematode. Members of the family Heteroderidae incite great changes in the plant root tissues. At the feeding site of females, a group of cells develop in to giant cell, which are multinucleate. Infection causes extensive changes in the root tissue due to hyperplasia and hypertrophy. Many other pathological changes due to nematode infection includes suppressed cellular division, root pruning and proliferation. All these effects vary with the nematode, host plant and other organisms present.

There are various estimates of the economic loss caused by nematode. The precise value can not be determined. Because of its " small size and hidden way of life" and lack of exact information on their occurrence and pathogenicity. Estimated overall average annual yield loss on world major crops due to plant parasitic nematodes is more than 12% Losses for the 40 crops in developed nations average 8.8% compared with 14.6% for developing nations. Global crop loss due to nematode on 21 crops, 15 of which are life sustaining were estimated at 78 $ billion annually. These figures are staggering, and the real figure, when all crops throughout the world are considered probably exceeds more than 100$ billion annually.

The problem of root-knot nematode becomes many folds when the nematode interacts with other microorganisms dwelling in the same niche. The effect is generally synergistic resulting in several fold damages to host plant. The major fungi that form the synergistic effect in association with root-knot nematode are *Fusarium, Rhizoctonia, Pythium, Sclerotium, Curvularia, Phomosis, Aspergillus, and Verticillium* etc. Root-knot nematode interacts with different viruses and phytoplasma. and causes more damage to the crops. The damage becomes even more in presence of stemborer (Stomopteryx nertaria) with root knot nematode on *Phaseolus aureus* than alone root-knot nematode

Management of root-knot diseases

Prevention:

- Education regarding nematode presence, biology, and management.
- Survey sampling of an intended planting site to determine the degree of existing nematode activity.
- Use of nematode free transplants. ·
- Careful examination of transplant roots before planting can prevent the introduction of nematodes that would attack present and future susceptible plantings. ·

Avoidance:

- Examples of avoidance tactics include: Sampling to determine nematode species and population levels
- Choosing plant materials that are poor hosts.
- Practice crop rotations that include no host, resistant and susceptible crops when feasible. Employ cultural practices known to be optimal for plant growth.
- Root barriers and container growing.

Suppression: Nematode suppressive tactics include: Cover crops and Green manures improve the fertility of the soil. As the plant material decays, the nutrients are released into the soil and are taken up by the subsequent crops planted in the soil. However, the time that is required for the cover crops or green manures to fully decay and penetrate to the root zone varies and can take up to an entire year. Both cover crops and green manures increase the bacteria, fungi, and other microorganism populations in the soil, which can aid in reducing root-knot numbers. When a cover crop is mixed into the soil, it is then referred to as a green manure.

Soil amendments, such as compost, oil seed cakes and manure, and mulches with high organic matter will increase the chances that root-knot antagonistic organisms will develop.

Crop rotation is the planting of different crops in different portions of the field/ garden each year. It is used to gradually reduce high populations over a number of years or to prevent a low population from becoming high.

Fallow period is with no susceptible plants for limited periods (in the area with high root-knot populations) can significantly reduce the population size.

Hot water treatment: The hot water treatment of the infested planting materials has been found effective for managing root-knot nematode population. For example treatment of root knot infected papaya seedlings at 50^0C for 10 minutes and incubation of potato tubers at 45^0C for 48 hours gave satisfactory control, where the field was not infested with nematode.

Resistant varieties this is one of the important method to avoid nematode population buildup and prevent root-knot nematode reproduction (reducing populations significantly). There is no need to have any special application techniques or equipment and have similar costs to non-resistant cultivars. They can be used in addition to other suppressive mechanisms such as crop rotation and soil amendments.

Soil solarization in this method of nematode control the uses of natural heat from the sun to reduce nematode populations. Prior to planting, when the soil can receive the most direct sunlight, it is covered with a plastic polyethylene tarp for four preferably six weeks.

Chemical nematicides: There are three types of chemical nematicides, which were used to control nematode problem on different agricultural crops.

Halogenated hydrocarbon: DD, EDB, DBCP, Chloropicrin, and methylbromide

Organophosphate: Parathion, Fensulfothion, Fenamiphos, Ethoprop, and Phorate

Dithiocarbamates: Aldicarb, Carbofuran, and Oxamyl

The chemical used in mid nineteenth centuries to control root-knot nematodes included the halogenated hydrocarbon like DD, EDB. Farmers of developed nations frequently used methyl bromide and DBCP and in India certain other chemicals nematicides were taken in to field like organophosphate and carbamates. The major organophosphate compounds were fensulfothion, phosphamidon, dichlorofenthion, fenamiphos, chloropyriphos, and ethoprophos. The major carbamates that were under trial were aldicarb, carbofuran, dimethioate, methomyl, thiodemeton, Oxamyl etc. But due to the high cost and their non-availability, the use of such chemicals in Indian subcontinent was limited. The only chemical carbofuran was in use in India to manage root-knot problem on different crops In 20^{th} centaury due the ban of major nematicidal compounds now researcher are more inclined to opt for some ecofriendly nematicides which may be organism or plant based.

Biological control: Several experiments were carried out to mange root-knot nematode population through the use of microorganism. Major emphasis was given on nematophagus fungi, egg parasitic fungi, nematode parasitic bacteria, PGPR, and AM fungi to manage root-knot

nematode problem of agricultural crops. Though, several non-chemical management tactics like fallow, flooding, changes in time of sowing / planting material, tillage practices, crop rotations, use of antagonistic crop, trap crop/ cover crop, use of nematode free planting materials or seeds, solarization, organic amendment and biological control are available, efforts are directed towards the use of microbes to minimize the plant parasitic nematode population and to make soil more suppressive to nematode diseases.

Rhizospheres are complex environment where several microorganisms interact with each other. The association of AM fungi with root bring a several changes in the plants as these fungal organism absorb nutrients which makes plants more healthy and induces resistance against several plant diseases. The AM fungi may produce metabolites with interaction root and may be toxic to different plant pathogen. The AMF colonize the root system and make a thick fungal mat around the root therefore alter other pathogen to infest the colonized root system. These fungi may change the physiology of the root system or compete with other organism for root colonization. There are several group of fungi associated with plant root system but for agricultural it is the arbuscular mycorrhizal fungi (AMF) of the Phylum Glomeromycota that are most important. AMF make active association with large number of plants except plant families of Brassicae and Chenopodiaceae, as these two families plant roots are not colonied by AMF. Generally the AM fungus consist of two phase as one part of fungus i.e. mycelium is inside the root and other parts are distributed in soil to form the hyphal net, which absorb the nutrient like soluble phosphorus, iron, and provide to plant for its health. The arbuscular mycorrhizal fungi generally increase uptake of immobile phosphate ion and in return the AM fungi gets carbon from the plants.

The mycorrhiza and plant parasitic nematode occupy root system and mycorrhizae are useful to plants, whereas phytonematodes are detrimental to plant yield. Mycorrhizal fungi become a useful tool to manage nematode population in one way but in other way it provide several useful effects on host plant to increase crop yield at significant level. Phytonematodes and arbuscular mycorrhizal fungi both are associated with plant root for their food and space. The major interest in such association is to provide increased plant resistance against phytonematodes. Symbiotic association of mycorrhizal fungi with plants provided a range of beneficial effect like enhanced micro and macro nutrient availability, provided resistance to plant against different biotic and abiotic factors and make healthy soil. Not only this much these mycorrhizal fungi also make associated plants more tolerant to heavy metal, drought resistance. However several agricultural practices like tillage, use of chemical fertilizers, monocultures, herbicides, nematicides, fungicides as well as growing non host crop of mycorrhizal fungi are highly harmful to such useful AM fungi. Even in organic cultivation these AMF provide sufficient nutrient to plants, well colonized the root system and reduced several inputs in crop cultivation. There is full evidence that these AM fungi reduced nematode problem at bay if used with other management practices carefully.

Different microbes has been exploited in this lab to reduce the population of plant parasitic nematodes below the economic threshold level and could play a significant role either singly or

can be integrated with other practices to develop integrated nematode management practices (INMP). Studies conducted at CIMAP, Lucknow so far indicate that microbial agents may play a significant role in limiting plant parasitic nematode population. The results of the studies carried out on major medicinal plants like *Artemisia annua, Withania somnifera, Rauvolfia serpentina, Bacopa monnieri* and aromatic plants like *Abelmoschus moschatus, Artemisia pallens, Mentha arvensis, Rosa damascena, Lavandula officinalis and Pogostemon cablin* (syn= patchouli) have proven the efficacy of microbial agents (*Paecilomyces lilacinus, Glomus aggregatum, Trichoderma harzianum, Glomus fasciculatum, Glomus mosseae, Pseudomonas florescens* etc.) and organic farming too in the management of nematode and for sustainable growth and yield of medicinal and aromatic plants.

Integrated nematode management practices: Since it is difficult to manage root-knot nematode population by a single method therefore attempts have been made to manage the population of nematode pest through integration of various methods together with major target of root-knot nematode. Our experiences are that root-knot nematodes are much more damaging since they are able to attack the roots at seedlings stage. My sincere suggestion is that it is important to protect susceptible crops from nematodes from very initial stages.

Molecular approaches for nematode management: Major advances in molecular biology and biotechnology has enabled the introduction and expression of pesticidal genes in to plant cells thus developing plant species resistant to the pest. Recombinant DNA technology would be of immense importance in introducing pesticidal genes in to root colonizing organism. It might soon be possible to develop " broad spectrum pesticides" which would act on different pathogens. Now people are developing different types of models to combat the plant parasitic nematodes by sequencing crops on the basis of the nematode preferences of crop and managing nematode population in ecofriendly ways without use of any nematicides.

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HPLC – An Important Tool for Assessment of Pesticide Residues in Export Commodities

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Developed countries like USA, Japan, Canada, Australia and the European countries are the major markets for our food exports. These countries have their own stringent food laws and regulations. The main objective of their laws is to protect the health and safety of their citizens. Their laws with respect to items of food are meant to protect the consumers from food of inferior quality, or those which are likely to be contaminated by impurities or poisonous substances. They allow import of food materials only when they conform to the provisions of their food laws and regulations.

Therefore any food item that we export, be it fruits, vegetables, marine products, cashews, pepper, cardamom or ginger, it is important that the product conforms to the quality standards demanded by the importing country. In the context of thousands of people getting infected with foodborne diseases or even dying of food poisoning, it is only just and reasonable that countries which depend on imported food stuffs should take such extreme precautions. Food materials that have become rotten, spoiled, infected with micro-organisms or contaminated by pesticides, heavy metals or any other impurities are either destroyed by the import inspection authorities or sent back to the exporting country. This not only results in loss of market but also damages the exporting country's reputation.

Right from the initial stages of production to the time till the produce reaches the consumer, the farmer has to combat many unfavorable circumstances. Among these are the pests which are highly devastating for the crops both in terms of quality and quantity of the produce. Micro-organisms may also infest the farmland and get into products from materials used in processing, or through unhygienic practices of the people who handle the produce.

A new consciousness is growing all over the world about disease-causing organisms, poisonous substances and impurities. Parallel to this, the degree of excellence which consumers expect from foods is also growing. Exporting countries are thus constrained to maintain quality standards set by the importing countries.

We export spices mostly to developed countries like USA, UK, Germany, other European Countries, Japan, Canada etc. These countries have very stringent food laws and regulations to ensure that foods which are being imported are produced under sanitary and hygienic conditions. Hence, any edible product exported into these countries

should be free from bacterial contamination, mold, mycotoxins, harmful chemicals including pesticide residues and other pollutants. The concern of the importing countries about food safety and quality is understandable as several cases of foodborne diseases and food poisoning occur in these countries as a result of consuming contaminated food.

Pesticide Residues

Pesticide residue refers to the pesticides that may remain on or in food after they are applied to food crops. The levels of these residues in foods is often stipulated by regulatory bodies in many countries.

Many of these chemical residues, especially derivatives of chlorinated pesticides exhibit bioaccumulation which could build up to harmful levels in the body as well as in the environment. Persistent chemicals can be magnified through the food chain, and have been detected in products ranging from meat, poultry, and fish, to vegetable oils, nuts, and various fruits and vegetables. The Environmental Protection Agency (EPA) sets limits on how much of a pesticide residue can remain on food and feed products, or commodities. These pesticide residue limits are known as tolerances. Tolerances are set to protect you from harmful levels of pesticides on your food. It is also termed as maximum residue limits (MRLs) for pesticides.

Export control and certification have to be supported by test facilities meeting the requirements of the importing country. While certifying different edible products for the export markets residues have to be tested at ppm and ppb levels and for this testing has to be done with highly sensitive instruments like HPLC, HPLC – MS, GC and GC – MS etc. Export certification has thereby led to strengthening test facilities and bringing them at par with those in the most developed countries. Out of different analytical techniques for estimation of pesticide residues, HPLC analysis is one of the best methods to detect the levels of several pesticide residues upto ppm levels.

High-performance liquid chromatography (HPLC) is a form of liquid chromatography to separate compounds that are dissolved in solution.

Compounds are separated by injecting a plug of the sample mixture onto the column. The different components in the mixture pass through the column at different rates due to differences in their partitioning behavior between the mobile liquid phase and the stationary phase.

Functional description of the HPLC instrument

The HPLC equipment has the following major components

Mobile phase reservoir

Pump

Injector

Column

Detector

Data system

The choice of appropriate mobile phase and column play a very important role in optimizing conditions for HPLC analysis. The mobile phase is less polar than the stationary phase in normal phase HPLC but in RP-HPLC it is more polar than the stationary phase. Solvents used as mobile phase must be degassed to eliminate formation of bubbles. The pumps provide a steady high pressure with no pulsating, and can be programmed to vary the composition of the solvent during the course of the separation. The heart of the system is the column where separation occurs. Since tthe stationary phase is composed of micrometre size porous particles, a high pressure pump is required to move the mobile phase through the column.

The chromatographic process begins by injecting the solute onto the top of the column. Separation of components occ ur as the analytes and mobile phase are pumped through the column. Eventually, each component elutes from the column as a narrow band (or peak) which is detected on the recorder.

Detection of the eluting components is important, and this can be either selective or universal, depending upon the detector used. The response of the detector to each component is displayed on a chart recorder or computer screen and is known as a chromatogram. To collect, store and analyse the chromatographic data, computer, integrator, and other data processing equipment are frequently used.

Quantitative analysis by HPLC

A calibration curve is plotted using the standard sample. The area of a peak is proportional to the concentration of the corresponding component. The concentration of the compound of interest can be determined from the peak area of the detected compound.

Use of HPLC in pesticide residue analysis

HPLC being a microanalytical technique, is often used for estimation of pesticide residues in edible as well as other commodities meant for export.

Vegetables and fruits are important ingredient of our food production having a high nutritional value. Vegetables like, okra, egg plant, spinach, cauliflower, tomato, pumpkin, carrots, turnips etc. and fruits like apple, orange, litchi, papaya etc. are produced in the

country for local consumption as well as for export purposes and therefore quantification of pesticide residues in them is essential.

HPLC method development for pesticides

The 3 critical components considered for developing an HPLC method for pesticide residues are:

sample preparation / extraction, HPLC analysis and standardization (calculations).

1. Sample preparation / extraction and cleanup

A comprehensive literature search of the chemical and physical properties of the analytes (and other structurally related compounds) is essential to ensure the success of the method.

Most sample preparations involve the use of organic-aqueous and acid-base extraction techniques. Therefore, literature survey is very helpful to understand the solubility and pKa of the analytes.

Solubility in different organic or aqueous solvents determines the best composition of the sample solvent. pKa determines the pH in which the analyte will exist as a neutral or ionic species. This information will facilitate an efficient sample extraction scheme and determine the optimum pH in mobile phase to achieve good separations.

2. HPLC analysis

The LC analysis of compounds can be challenging. Suitable selection of solvent for mobile phase and a proper choice of column is essential. The λ max of the compound of interest is determined and thereafter the pesticide is injected.

The data is obtained in the form of peaks and for recording the data high speed computers are used. Recorded data can further be manipulated on the basis of comparison for identification of the compound of interest.

3. Calculations / Data analysis

The data should always be in triplicate so that it can be subjected to stastistical analysis. The primary data alongwith S.D or C.V are usually reported in tabular form. They show the spread of the data and are a measure of precision. The residue data can also be presented in graphical form as a persistence or dissipation curve and with the help of these curves the half life values of pesticides can be calculated.

Development/ modification of extraction procedures of pesticide residues from vegetable samples

Extraction and cleanup of imidacloprid insecticide from vegetables: A representative chopped vegetable sample (25 g) is taken in a wide mouthed conical flask and extracted twice with 50 mL acetonitrile. The combined extract is partitioned with hexane. The lower

hexane phase is collected and re-partitioned with hexane: ethylacetate (98:2). The lower hexane-ethyl acetate layer is collected and partitioned with dichloromethane (DCM). The DCM layer is collected and passed through anhydrous sodium sulfate and then evaporated to dryness. The residue obtained is dissolved in 10ml ethyl acetate and passed through a column containing 4.5gm florisil sandwiched between anhydrous sodium sulfate. The imidacloprid residues are eluted with ethyl acetate. The eluate is concentrated to dryness and the residue is dissolved in acetonitrile for HPLC analysis.

Extraction and clean up of carbendazim fungicide from vegetables: A representative chopped vegetable sample (25 g) is taken in a wide mouthed conical flask and extracted with 50 mL methanol. The samples are shaken for one hour and subsequently filtered through a buchner funnel and washed with 25 mL methanol. The combined filtrate is reduced to 15mL in a rotatory flash evaporator at 60±2°C and transferred to a 500 mL separatory funnel containing saturated aqueous sodium chloride solution (10 mL) and distilled water (80 mL). Carbendazim is extracted from the aqueous solution with dichloromethane (3x50 mL). After partitioning the organic phase is collected. The combined extract is dried on anhydrous sodium sulphate and evaporated to dryness under vacuum at 40±2°C. The residue is dissolved in dichloromethane and the final volume adjusted to 10 mL. For clean up studies the dichloromethane extract is purified by the following methods. The column is packed with silica gel (200-400 mesh), anhydrous sodium sulphate and activated charcoal. It is conditioned with 10 mL dichloromethane and the sample solution is transferred to the column. Carbendazim is then eluted with 50 mL dichloromethane and ethyl acetate (4:6) v/v. The eluate fraction is evaporated to near dryness and the residue is redissolved in 2 mL methanol for final HPLC analysis.

HPLC analysis.

Mobile Phase, 80:20 (Methanol:Water v/v) at a flow rate of 0.5ml/min; Wavelength (λ_{max}), 280 nm; and Column, RP – 18 (250mm x 4.6 mm ODS 5µm) are used for estimation of carbendazim and imidacloprid. Residues are estimated by comparison of peak areas of the standards with that of the unknown samples run under identical conditions.

Extraction and clean up of fipronil herbicide from soil: 25 gm soil is taken in a conical flask and enough acetone is added to dip the soil. The samples are stirred and kept for 30min. with constant shaking. Soil contents are filtered , transferred back to conical flask and re-extracted twice using fresh acetone. The extracts are transferred to separatory funnel and diluted with saline solution. DCM is added for partitioning. The DCM layer is

collected and evaporated to dryness. The residue is dissolved in mobile phase for HPLC analysis.

HPLC analysis

Mobile Phase, 70:30 (Methanol:Water v/v) at a flow rate of 1.0ml/min; Wavelength (λ_{max}), 276 nm; and Column, RP – 18 (250mm x 4.6 mm ODS 5µm) are used for estimation of fipronil. Residues are estimated by comparison of peak areas of the standards with that of the unknown samples run under identical conditions.

Devising an Integrated Apple Disease Management Programme through Antagonists, Need Based Fungicides and Farmer Advisory Services

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Apple is attacked by a large number of diseases. Specific type of agro ecosystems will have a typical disease complex in a given area, in which some disease species play a more prominent role than others. Rather than deal with all disease management problems in a given agro ecosystem, it usually is more efficient to prioritize problems and develop an IDM program around the most important, or key diseases. Key diseases can be determined using several factors, (1) the potential for economic damage (ii) the relative amount of management needed (particularly chemicals), and (iii) the availability of some form of alternative management technique. The apple pest control recommendation at that time indicated that growers using a strict calendar-based schedule might make from eight to 10 fungicide application for a number of diseases, four to six insecticide-miticide applications for several arthropod pests, and two to three herbicide application to manage weeds in orchards. Apparently, growers had already realized that the calendar-based recommendations were excessive. Next, we sought established IDM methods to control the key diseases. On this basis we concluded that in Uttarakhand, the best chance for rapid introduction of IDM methods involved management of powdery mildew, scab, pre-mature leaf fall and canker with use of least amount of fungicides.

Apple powdery mildew, caused by *Podosphaera leucotricha* (Ell. & Ev.) Salm., has become a persistent disease problem on susceptible cultivars in the apple growing belts of Uttarakhand and the incidence varied at different locations and in cultivars. Economic damage from powdery mildew in bearing orchards results from reductions in tree vigor and blossom bud production, aborted blossoms, and fruit russetting. Infection can reduce trunk growth, fruit size, crop weight, and value. Severe infection can reduce the amount of bloom and almost eliminate the crop the following season. In nurseries and young plantings, mildew stunts tree growth and causes poorly formed, misshapen trees. The apple powdery mildew fungus over winters as mycelium in dormant blossom and shoot buds produced and infected the previous growing season. Conidia, the primary inoculum, are produced and released from the unfolding leaves as they emerge from infected buds. Abundant sporulation from over wintering shoots and secondary lesions on young foliage leads to a rapid building in inoculum. Secondary infection cycles may continue until susceptible tissue is no longer available. The cleistothecia / perithecia was found on one year old mildew affected twigs of bearing of apple trees in the mid summer at high altitude areas (>2000) but are not considered an inoculum source because the ascospores they contain fail to germinate readily.

As the use of resistant varieties is an effective tool of management against it, 36 apple cultivar were evaluated in the Horticultural block of GBPUAT, Hill Campus, Ranichauri, to explore new sources of resistance of the screening material, eight cultivars (Honey Sweet, Scarlet Spur,

Oregon Spur, Well Spur, Rymer, Top Red, Summer Red, Lord Lambourne) had high levels of resistant (mildewed area rating, 0 on a scale of 0 – 9), during all three years. The disease was low in most of the cultivars (Red Delicious, Tydman's EW, Golden Delicious, Amb Starking, Red Gold, Rich-A-Red, Royal Delicious, Amb Red, Amb Rich, Vance Delicious, Red Royal and Starkrimson) whereas cultivars namely (Red Chief, Mollies Delicious, Braeburn, Bakingham and Early Shanberry) were highly susceptible with index more than 5%. Young apple nursery seedlings were also highly prone to disease. The cultivars found resistant or moderately resistant may be used in breeding programs.

Development of powdery mildew infection on five popular cultivars of apple viz. Scarlet Gala, Golden Spur, Mollies Delicious, Red Fuzi and Red Chief, several biochemical changes occur in the trees. Among these, change in phenolic acid content is also one among them which plays a great role in resistance or susceptibility of plants was also observed. Scarlet Gala and Red Chief are very rich in phenolic acids, and had showed moderate susceptibility to the pathogen but some cultivars; Golden Spur, Mollies Delicious and Red Fuzi are highly susceptible, which showed very small amount of phenolic acid, viz., Gallic, Caffeic, Venillic, O-coumeric, Cinnamic and Salicylic acid. Thus, the presence of these secondary metabolites (phenolic acid) can be taken as a biochemical parameter in screening apple cultivars for resistance / susceptibility against powdery mildew of apple.

Control of powdery mildew of apple by plant growth promoting rhizobacteria (PGPR) and talc – based formulation of aerial spray has been tried under field conditions. Strains of *Pseudomonas fluorescens* and *P. aeruginosa* have been used in this experiment. *P. aeruginosa* and talc–based *P. fluorescens* strain 173, elicited systemic protection against powdery mildew on apple and reduced disease severity. Germination of conidia of *P. leucotricha* on leaf surface of apple plants treated with the PGPR strain, talc–based formulation and chemicals, was significantly reduced. The talc–based PGPR strain 173 and *P. aeruginosa* will be a better avenue for the control of apple powdery mildew.

The efficacy of two plant products viz., ajoene, a constituent of garlic (*Allium sativum*), and neemazal, a product of neem (*Azadirachta indica*), were inhibitory to conidial germination on glass slide and on apple leaves (5, 10, 15, 20, 25 µg ml^{-1}). Ajoene showed complete inhibition at the highest concentration (25 µg ml^{-1}). Neemazal was also inhibtoiry but not to the extent of ajoene. Different concentrations of ajoene (150, 250, 500, 750, 1000 µg ml^{-1}) and neemazal (50, 100, 150, 200, 250, 300 µg ml^{-1}) were significantly reduced the intensity of powdery mildew of apple seedling as compared to control. Neemzal was more effective than ajoene even at lowest concentration. The efficacy of mixture of ajoene and neemazal (750: 150 µg ml^{-1}) provided 100 per cent reduction over check. The antisporulant activity of the fungicides and two plant products viz. ajoene and neemazal (1000 and 250 µg ml^{-1}) inhibited sporulation of *P. leucotricha* after each days (7, 14, 21 and 28 days). Sporulation started after 14 and 21 days in Ajoene and Neemazal treated leaves. After 28 days of treatment, sporulation occurred in all the treatments with minimum

spore production of 0.13 x 10^4 was found in Bavistin whereas the neemazal treated seedling showed the spore production of 0.36 x 10^4 . Both plant products and fungicides inhibited spore production by 100 per cent up to 7 days and Neemazal and Bavistin were effective up to 14 and 21 days.

The presence of *Ampelomyces* spp. was quantified in naturally occurring powdery mildew fungi collected from 10 sites of District Tehri Garhwal. Pycnidia of *Ampelomyces* were found in 34 per cent of the collected samples. Maximum mycoparasitism was recorded in the cultivar Mollies Delicious followed by the Bakingham. The incidence of *Ampelomyces* spp. determined as the proportion of samples, in which intracellular pycnidia were present, varied between 0 to 24.7 per cent in *P. leucotricha* of apple. The intensity of mycoparasitism, defined as a percentage of the powdery mildew mycelia parasitize by *Ampelomyces*, ranged from 0.0 to 11.42 per cent. Both the incidence and the intensity of mycoparasitism showed the highest value in cv. Mollies Delicious. The mycoparasitism in *P. leucotricha* of apple leaves wee isolated and identified on the basis of morphological characters with the help of taxonomic key. The antagonistic activity of *A. quisqualis* was also seen on the growth inhibition of *P. leucotricha* on apple leaves under polyhouse conditions in plastic pots. Maximum growth inhibition (63.54%) was observed in case of 10^6 spore concentration / ml of *A. quisqualis* followed by 52.61 per cent at 10^5 ml^{-1} and minimum (22.45%) at 10^3 ml^{-1} spore concentration.

The spore of *A. quisqualis* alone, significantly decreased disease incidence and severity. However, plant products alone or in integration with the mycoparasite showed significant effect on incidence and severity of powdery mildew. The maximum protection (89.2%) was obtained in alternated spray in 2 weeks of *A. quisqualis*, ajoene and neemazal treatment followed by mixture of ajoene and neemazal (100 + 250µg ml^{-1}) and *A. quisqualis* once in every 4 weeks. Integrated spray schedule improved protection from powdery mildew without affecting further development of the seedlings of apple.

Apple Scab

Surveys for prevalence and severity of apple scab disease conducted in Garhwal Himalayas revealed severe disease incidence in the Batwari fruit belts. The incidence of scab ranged between 05 to 65 per cent on foliage and 5 to 35 per cent on fruits. Earlier leaf fall resulted into better decomposition of apple leaf litter during the overwintering stages after urea treatment. The decomposition rate for samples collected up to 15 November indicated 96% intact leaves compared with are 100% in untreated samples after month overwintering period, whereas on 25 February it was recorded that treated leaves had 7% complete decomposition, 31% were left with midrib portion, 40% partial and 22% intact leaves as compared to 97% intact leaves in checks. Though the observation revealed significant effect of urea in leaf decomposition over untreated but the decomposition rate and the extent was not significant in relation to the leaf fall dates.

Pseudothecia development started from November and December and progressed steadily when moisture and temperature conditions were favorable under Uttaranchal hills. The

pseudothecia continued to develop ascus from the end of February until April, and ascospores discharged between May to June in Harsil fruit belt. The potential ascospore dose for each orchard was the product of the lesion density, leaf litter density, pseudothecial density, ascus density and number of ascospores per ascus. PAD was calculated in different orchards of integrated managed (IM), well-managed (WM), moderately managed (MM) and poorly managed (PM) groups. On this basis, scab incidence was classified into small, medium and high in integrated managed, well managed, moderately managed, and poorly managed orchards, respectively. In poorly managed orchard, only 2 to 28 per cent of the total discharge was observed during most of the meteorological weeks. The ascospore discharge were severe in the week 23, moderate in 22 and 24 and low in early instances in all the years. Leaf litter density values were generally equal (30-46%) in IM, WM, MM and PM orchards at most of the experimental sites. The ascospore production per m^2 orchard floor was the lowest in IM orchards and was much higher in PM orchards during all the years. PAD values were low in IM orchards at Harsil fruit belt when compared to PM fruit belt for the reason that the crop was properly managed by Urea/ bio-control agents and EBI fungicides (Flusilazole) at different phonological stages of apple. In IM orchards, last fungicide spray was given 15 days before harvest and sprays of 5 per cent urea or antagonist were given at leaf fall, which could be the reason for the low PAD values, in spite of weather conditions being favorable. In Gangotri valley, we observed different PAD levels in IM orchards and thus reduced sprayings were effective.

Recently, scab warning service has been organised in the most important apple growing district, based on electronic scab warners. Scab forewarning service carried out under NATP, ICAR, UCOST and NAIP project is being followed in Uttarakhand hills. Such forewarning, which usually begins in the early spring, predicts the time when initial disease may develop and when the threat of primary scab is over, and helps the orchardists in efficient use of spray chemicals. The development and computation of mathematical models or predictive equations, and automatic monitoring of weather data for apple scab, majority of the orchardists in Garhwal hills and several other places of India still rely on initiating the first spray at green tip to early petal fall stage in spring, and following a 10 day spray schedule thereafter till the primary scab season is over. The above information collected from experimental sites on the infection period is passed on to the orchardists by blowing a characteristic signaling, telephonic communication, SMS, local news paper, Govt. organization and through personal contacts or messages flashed 4-5 times through “All India Radio, Nazibabad” on the urgent need to undertake immediate spray or to reschedule already recommended spray programme. Such forewarning has benefited the grower in minimizing damages due to scab and also reduce fungicide usage.

Premature Leaf fall of apple is also known as Marssonina blotch since it is caused by *Marssonina coronaria* (Ell. And J.J. Davis) J.J.Davis (Syn. *Marssonina mali*). The disease first appears after rains in the month of June to August and is characterized by sudden yellowing of the mature whorl of leaves. Affected leaves show dark brown circular spots of 4-8 mm diameter, which coalesce to

form larger blotches. The disease also attacks mature fruits, they show circular dark brown spots of 3-6 mm diameter. Dark coloured pin head like acervuli are visible in the necrotic spots both on leaves and fruits. The fungus causes mid season defoliation in apple orchards resulting in a heavy loss due to poor quality fruit and adversely affects plant health and bearing capacity. The level of blotch infection on leaves was much high in Garhwal & Kumauan fruit belt i.e. 39 to 42 percent respectively. The disease has been controlled by broad-spectrum fungicides or timely spray of fungicides under spray schedule for scab.

Sooty blotch [*Gloeodes pomigena* (Schw.) Colby] and **fly speck** [*Schizothyrium pomi* (Mont. & Fr.)Arx, the anamorph of *Zygophiala jamaicensis* E. Mason] diseases of apple are of annual occurrence in late summer with the onset of rains, and these continue to increase in severity with the prevalence of high atmospheric humidity during the months of July to September. Sooty blotch and fly-speck (SBFS) cause superficial, dark colored blemishes on the skin of apple fruit. Severely affected fruit are virtually unmarketable except for juice, and multiple small infections exclude fruit from grades according to Indian grading standards. The timely sprays of Benomyl, thiophanate-methyl and mancozeb were all highly effective against SBFS. The spray schedule was also able to reduce SBFS by 95.02 and 90.08 percent respectively. High relative humidity and heavy rainfall favour the development of leaf spots, sooty blotch and flyspeck diseases of apple and these initiate with the onset of rains.

Canker is a diseased area on the stem or branch usually well defined this often results in the death of the bark within infected area. Among them stem and branch cankers cause huge losses through girdling of branches, limbs and die-back of twigs resulting in death of plants. The infected bark becomes depressed and sometimes blisters are formed on it, which often exude watery liquid on the surface of the lesion. The stem brown canker produces numerous pimple-like protuberances and fruiting bodies of secondary fungi on the bark and stromata underneath it. The shoots above the cankered lesion show dieback and become wrinkled. Wood below the bark is necrotic and stained dark brown. Stem black canker developed long vertical cracks containing black powder in the bark resulting in blackening of branches which later die. Pink canker starts infections from the forks of branches and proceeds both upwards and downwards. Usually the lesions are sunken, dull brown with cobweb like growth. In rainy season, the mycelium remains superficial and transforms into pinkish incrustation. Often the mycelium penetrating the bark enters the wood and results in death or blight of terminal parts.

Various cankers induce varied type of symptoms depending on the fungus and climatic conditions of the orchards. It is very difficult to estimate the loss incurred due to canker since many factors are involved. Faulty pruning over the years, adverse weather conditions, and wound/ injuries caused while undertaking agronomical practices and also by insect-pests, favour canker development. Severity of cankers is more in marginally situated apple orchard (1000-1400 m. asl.), where the chilling hours (>1400 hr when temperature must be below 6°C) requirement is not met with completely. Effective schedules have been developed for controlling canker diseases,

comprising of an application of COC (0.3%) after fruit harvest and pruning along with dressing the pruning wounds and cankered lesions with paints like Bordeaux, Chaubattia, Blitox, Benomyl and cowdung pasts, has been highly effective.

Root Rot is caused by two different fungi, *Dematophora necatrix* (White root rot) and *Phytophthora cactorum* (Collar rot) in apple trees has been increasingly imposing problem and resulting in the death of plant. White root rot symptoms occur on lateral roots, which turn into dark brown colour and become infested with white flocculent fungus during monsoon months. During rainy season white mycelia mat can be seen in the soil and roots. Collar rot infection starts from the collar region and spread mostly to the underground parts and the above ground stem portion is also infected in highly susceptible cultivars. The leaves turn yellow and fall pre-maturely during severe infection. Root rot affected trees are usually associated with a heavy blossom and fruiting next year, however in succeeding years, few leaves emerge and much of the immature fruits induce early colouration and fail to reach maturity. Severity in years leads to die-back/ drying of twigs and branches. Root rot infected trees often persist for 3-4 years depending upon the infection of the fungus. Temperature and soil moisture has been known to play an important role in the survival and spread of the pathogen.

The prevalence of root rot in Uttarakhand is limited to high hill soil texture varies from loam to clay loam. The soil reaction is slightly acidic and this zone is ideally suited for apple cultivation. It receives an average of 90-150 cm rainfall per annum. The rainy season in the apple zone is during 2nd week of June to last week of August, severe incidences of root rot are observed in Garhwal and Kumauaon region. The high altitude areas were observed favourable for the spread of root rot being high rainfall and low temperature conditions prevailing for long durations. Cultural practices are more helpful in restricting the disease spread. Drenching with Mancozeb or Blitox in 30 cm radius around the trunk and foliar spray of Fosetyl-aluminium are completely controls the collar rot disease and increase growth and fruit yield. Lime (November or December) and copper sulphate (April to May) were mixed in the soil and drench 1-2 ft deep holes around the tree basin with carbendazim in the month of rainy season or after rain for the control of white root rot.

Apple IDM Program

The above observations depict the periods during a growing season when various diseases are active and many require specially timed control measures. The phenology of tree and time are more important in scheduling control measures. Fungicide sprays are generally applied between silver/ green tip and pink bud stage to control scab, and a pre pink oil spray may be used to reduce populations of insects. After 12-15 days, at petal fall, the fungicides were used for the control of several disease i.e. scab, powdery mildew, black rot and calyx end rot. Powdery mildew, pre-mature leaf fall, fruit rots, and several minor diseases may also require treatment at this time, dependent of location, and weather. The insecticide sprays may be required often June and July to control specific pest problems. Fungicidal protection against apple scab is continued, but the conditions may be influenced by a need to control sooty blotch and flyspeck. In

Uttarakhand, approximately 8 to 10 fungicides sprays and four to five insecticide sprays are applied during a single year in a protectant spray programme. Fungicides are applied at approximately 7-day intervals during the primary infection period and it will increased up to 14 days during secondary scab infection season. An unexpected rain may force growers to apply a postinfection spray for scab only 3 or 4 days after fungicide/ insecticide application. Fungicide applications for control of scab and other diseases have been recommended for many years on the basis of trials conducted in farmer's field at Gangotri fruit valley with large overwintering population of the apple scab fungus. Gadoury and MacHardy described a method to quickly and easily obtain an estimate of the PAD (ascospores per square meter/ year) in commercial orchards. We have used forecasts of PAD to determine when early-season fungicide sprays for apple scab could be omitted. We estimate over 15 years of fungicide trials in Gangotri valley, where weekly applications of protectant fungicides such as captan, dodine, carbendazim and mancozeb have provided excellent control of apple scab in farmers orchards where PAD was in between 75,000 to 1, 25,000 ascospores per square meter per year. No fungicides with extended protectant activity are currently available to commercial growers, but sterol-inhibitor fungicides are perhaps the ideal compounds on the basis of their spectrum of activity and potential for post infection control of scab and mildew. In the last 15 years of trials in Gangotri valley, we have not encountered the situation where extended protectant or postinfection activity was needed in the petal fall sprays. In area where sooty blotch and flyspeck are problems, the interval between fungicide sprays can be extended from 20 to 25 days if dithiocarbamate fungicides are used.

Scab predictive and warning service in Uttarakhand hills: Apple scab forewarning service carried out under NATP, ICAR, UCOST and NAIP project is being followed in Uttarakhand hills. Such forecasting, which usually begins in the early spring, predicts the time when initial disease may develop and when the threat of primary scab is over, and helps the orchardists in efficient use of spray chemicals. The maturity and discharge of ascospores usually coincide with the pink bud to petal fall stage of the tree in Uttarakhand. The quantity of primary inoculums is measured as (1) ascospore discharge (productivity) based on number of mature spores/ cm^2 on overwintered leaf area and (ii) ascospore dose, which is the number of spore/ volume of air (iii) The infection period of the pathogen are monitored by measuring leaf wetness period, ambient temperature and arriving at the period through the modified Mills table. Besides infection period, periodic information on the maturation and discharge of ascospores, degree-day for cumulative ascospores maturation and PAD are also collected from different fruit belt, forecasting the time and extent of primary infection. To collect systematically all this basic information from different place of Uttarakhand hills and issue the forecast under above said project. Ascospore dose measures the actual inoculums concentration in the orchard air at different stages of host phenology and this is dependent on ascospore productivity and factors that influence spore release i.e. air temperature, light, time of days, climatic date, and leaf wetting by rain/dew. Numbers of traps are available for monitoring of ascospores dose in the air. The percentage of coloured spores increased week by

week until about bloom to early petal fall stage of 'Delicious, cultivar and then diminished in Uttarakhand hills. Much reliance is given for spray programme commencing at Green tip to early petal fall stage of apple trees, and continuing the fungicidal spray at short intervals until the primary scab season is over. Such protective spray in the form of SAT (single application technique) or RSAT (reduced doses in SAT) are commonly practiced in several countries. Looking into 20 years data on tree phenology at Garhwal hills, is confident of utilizing tree phonological stages in developing a predictive equation for improving chemical control strategy.

Mills defined the 'conditions' of temperature and hours of leaf wetness needed for infection, referred to as modified Mills period or table. Increase in hours of wetting at any temperature would increase the number of infections. Based on the occurrence of infection period, the type and rate of fungicide, and their frequency application are taken into account in most of the places, for keeping orchards almost free of scab infection. In Uttarakhand, apple scab predictor and µMETOS were able to predict infection periods correctly as tagged leaves showed new scab lesion accordingly. The Revised Mill's Table indicate the minimum number of hours of continuous wetting periods required for primary infection of apple leaves by ascospores of *Venturia inaequalis.*. Some ascospores are discharged at night or rain begins after sunset, so hours of leaf wetting should be computed from sunrise.

Predictive models are developed for determining ascospore maturity and an equation using multiple regression analysis for Uttarakhand hills. The equation shows that maturity depends to a larger extent on the number of accumulated degree days from leaf fall, and to much a lesser extent on accumulated precipitation during the same period. We also developed a linear statistical model based on the accumulated degree days from the maturation of ascospore and PAD. The development and computation of mathematical models or predictive equations, and automatic monitoring of weather data for apple scab, majority of the orchardists in Garhwal hills and several other places of India (HP) still rely on initiating the first spray at green tip to early petal fall stage in spring, and following a 10 day spray schedule thereafter till the primary scab season is over. The above information collected from experimental sites on the infection period is passed on to the orchardists by blowing a characteristic signaling, telephonic communication, SMS, local news paper, Govt. organization and through personal contacts or messages flashed 4-5 times through "All India Radio, Nazibabad" on the urgent need to undertake immediate spray or to reschedule already recommended spray programme. Such forewarning has benefited the grower in minimizing damages due to scab and also reduce fungicide usage.

Apple scab disease predictive information, ascospore release data and other important apple diseases management data of the Garhwal and Kumauon region are available from our University centres. There are also field days for apple growers sponsored by research project and chemical companies. At these field days, personnel from our University may present information useful to growers. Thus, with its many and diverse public and private partnerships, GBPUAT is instrumental and providing Garhwal apple growers with research based disease management advice.

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Soil Solarization: A Nonchemical Disease Management Strategy

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Several methods have been developed for the management of diseases incited by various plant pathogens, which include fungicidal application, breeding for disease resistance, sanitation, crop rotation, biological control and soil disinfestations. The need for different methods of plant disease management stems from the fact that usually none of them is perfect nor can anyone be used under all circumstances. Moreover, the life cycles of pathogens may vary in different crop systems, thus requiring different management strategies. Therefore, any new method of disease management is of value since it adds to our rather limited arsenal of control methods. This is particularly true with innovative non chemical approaches which are needed to replace hazardous chemicals.

The concept of managing soil borne pathogens has now changed. In past, control of these pathogens concentrated on eradication. Later it has been realized that effective control could be achieved by interrupting the disease cycle, plant resistance or the microbial balance leading to disease reduction below the economic injury level, rather than absolute control. The integrated pest management concept encompasses many elements. In this context, soil solarization can play a significant role. Soil solarization is a non-chemical soil disinfestation method applied worldwide for the control of soilborne plant pathogens, weeds and nematodes.

In Israel, extension workers and growers suggested that the intensive heating that occurs in mulched soil might be used for disease control. By mulching the soil with transparent polyethylene sheets in the hot season prior to planting, a team of Israeli workers developed a solar heating approach for soil disinfestation. Soil solarization is a method of controlling soil borne pests and pathogens by raising the temperature of the soil through application of transparent polyethylene sheet to a moist soil surface. With solarization vast possibilities for disease control are possible. Soil solarization as a disinfestations method, has potential advantages. It is a non chemical method which is not hazardous to the user and does not involve substances toxic to the consumer, to the host plant or to other organisms. In the right perspective it is less expensive than other methods. This technology can easily be transmitted to the farmers and can be applied in large areas manually and mechanically. It may have a long term effect, since effective disease control lasts for more than one season. This method has the characteristics of an integrated control, since physical, chemical and biological mechanisms are involved and because the control of a wide variety of pests is achieved.

Use of this method has been reported to reduce the population of many soil borne pathogens including fungi bacteria and nematodes as well as weeds (Pullman *et al*.,1981; Katan *et al*., 1983; Barbercheck *et al*; 1986; Verma *et al*; 2005). Soil solarization applied singly or in combination with biocontrol agents or reduced doses of soil fumigants/fungicides has shown a remarkable

destructive effect on most soil borne plant pathogens.

Various terms like solar heating, plastic or polyethylene tarping, polyethylene or plastic mulching of soil have been used to describe this method. Since this method involves repeated daily heating at relatively mild temperatures, the term solar pasteurization has also been suggested.

Principles

Heat is used as a lethal agent for the control of plant pathogenic organisms through the use of transparent polyethylene soil mulches (tarps) for capturing solar energy. Polyethylene covering of soil induces green house effect and raises soil temperature. The following recommendations are made to bring about effective solar heating of soil:

- Transparent (clear) not black polyethylene should be used since it transmits most of the solar radiation that heats the soil. Black polyethylene, though it is greatly heated by itself, is less efficient in heating the soil than transparent sheet.
- Soil mulching should be carried out during the period of high temperatures and intense solar irradiation.
- Soil should be kept wet during mulching to increase thermal sensitivity of resting structures such as sclerotia, chlamydospores, etc. and to improve heat conduction.
- The thinnest possible polyethylene tarp (25-30 µm) is recommended, since it is both cheaper and more effective in heating, due to better radiation transmittance, than the thicker one. Polyethylene reduces heat convection and water evaporation from the soil to the atmosphere. As a result of the formation of water droplets on the inner surface of the polythene film, its transmissivity to long wave radiation is highly reduced, resulting in better heating due to an increase in its greenhouse effect. An ideal plastic mulch is that which is 100% transparent to solar radiation and completely opaque to long wave radiation. This ideal mulch can increase soil temp. by 6-8^{0}c over ordinary polyethylene.
- Since temperatures at the deeper soil layers are lower than at the upper ones, the mulching period should be sufficiently extended, usually 4 weeks or longer, in order to achieve pathogen control at all desired depths.

The solar heating method for disease control is similar, in principle, to that of artificial soil heating by steam or other means. There are, however, important biological and technological differences: (i) With soil solarization there is no need to transport the heat from its source to the field. (ii) Solar heating is carried out at relatively low temperatures as compared to artificial heating; thus its effects on living and nonliving components are likely to be less drastic. Negative side effects observed with soil steaming such as phytotoxicity due to release of manganese or other toxic products and a rapid soil reinfestation due to the creation of a biological vacuum have not been reported so far with solar heating.

Absorption of solar radiation in different soils varies according to the colour, moisture, and

texture of the soil. In general, the soil has high thermal capacity and is a poor heat conductor thus resulting in a very slow heat penetration in soil. The energy is lost from the soil in the form of long wave radiation through conduction, convection, and water evaporation. The principles of solar heating in polyethylene mulched soil were demonstrated by Waggoner *et al*., 1960. If thermal processes occurring in mulched soil are considered, then soil temperatures at the desired depth can be predicted. Mahrer, 1979 developed a one dimensional numerical model for such predictions. As per this model in wet, polyethylene mulched soil, increased temperatures are due primarily to the elimination of heat loss by evaporation and heat convection during the day time and partially to the green house effect (preventing part of the long wave radiation from leaving the ground). By predicting the temperatures at any depth of the mulched soil, the model enables us to select the suitable climatic regions and the time of year most adequate for solarization of soil, providing data on the heat sensitivity of the pathogens and their population density at various depths are available. Relative importance of type of mulching material, soil type, moisture and climatic factors can also be evaluated. Analysis of the spatial soil temperature regimes in mulched soil showed that heating at the edges of the mulch is lower than at the center, and that a narrow mulch strip is less efficient in heating than a wider one (Mahrer and Katan, 1981).

Mechanisms

Reduction in disease incidence occurring in solarized soils, results from the effects exerted on each of the three living components involved in disease (host, pathogen, and soil microbiota) as well as the physical and chemical environment which, in turn affects the activity and interrelationships of the organisms. Although these processes occur primarily during solarization, they may continue to various extents and in different ways, after the removal of the polyethylene sheets and planting. The most pronounced effect of soil mulching with polyethylene is a physical one, i.e. an increase in soil temperatures, for several hours of the day. However, other accompanying processes such as shifts in microbial populations, changes in chemical composition and physical structure of the soil, high moisture levels maintained by the mulch, and changes in gas composition of the soil, should also be considered while analyzing mechanisms of disease control. The following equation proposed by Baker (1968), for relating the various factors involved in biological control, should be adopted for this analysis:

Disease severity =inoculum potential x disease potential, where inoculum potential is the energy available for colonization of a substrate (infection court) at the surface and disease potential is the ability of the host to contract disease. More specifically the equation becomes:

Disease severity = (inoculum density x capacity) x (proneness x susceptibility), where capacity is the effect of the environment on energy for colonization, and proneness is the effect of the environment on the host. Of these four components, inoculum density (ID) is the one most affected by solarization either through the direct physical effect of the heat or by microbial processes induced in the soil. The other components, however (except for susceptibility which is genetically determined) might also be affected.

Thermal inactivation of pathogens

Whenever microorganisms are subjected to moist heat, at temperatures exceeding the maximum for growth, their viability is reduced. The thermal death rate of a population of an organism depends on both the temperature level and exposure time, which are inversely related. At a given temperature and time of exposure, mortality rate is related to the inherent heat sensitivity of the organisms and to the prevailing environmental conditions. In general, populations of soil borne fungal pathogens are drastically reduced at temperatures of 40-50^{0}C, exposure time ranging from minutes to hours for the higher temperatures, and up to days for the lower temperatures. The response of the population to elevated temperatures depends on propagule type, age and on environmental factors like pH, presence of ions etc. Presence of moisture is a crucial factor since microorganisms are much more resistant to heat under dry conditions. The effect of water can be explained by the dependence of the heat stability of proteins on hydration. In the presence of water less energy is required to unfold the peptide chain of proteins, resulting in a decreased heat resistance. Heating dry soils is therefore not effective in pathogen control (Katan *et al.*, 1976).

Biological control

Microbial processes, induced in the soil by solarization, may contribute to disease control, since the impact of any lethal agent in the soil extends beyond the target organisms. If induced by solarization, biological control may affect the pathogen by increasing its vulnerability to soil microorganisms or increasing the activity of soil microorganisms toward pathogen or plant, which will finally lead to a reduction in disease incidence, pathogen survivability, or both. Thus both short and long term effects might be expected. Biological control may operate at any stage of pathogen survival or disease development during or after solarization, through antibiosis, lysis, parasitism, or competition.

Disease Management

Soil solarization has been demonstrated to control diseases caused by many fungal pathogens such as *Rhizoctonia solani*, *Fusarium* spp., *Pythium* spp., *Phytophthora* spp., *Verticillium* spp., *Sclerotium rolfsii* etc. in many crops (Katan *et al*., 1983; Abdul *et al*., 1995; Raoof and Rao,1997). Soil solarization has also been shown to significantly decrease the population of disease causing Agrobacteria and *Pseudomonas* (Raio *et al*., 1997; Chellemi *et al*., 1994). Soil solarization has also been used to control many species of nematodes. However, as nematodes are relatively mobile, may survive solarization deeper in the soil profile and recolonize soil rapidly, soil solarization may not always be as effective as in controlling fungal disease and weeds. Diseases caused by *Meloidogyne* spp., *Heterodera* spp. etc.have been successfully controlled by soil solarization (Rao and Krishnappa, 1995; Grinstein *et al*., 1995).

Weed Control

Solarization results in an effective weed control lasting in some cases for more than two or three seasons (Abdel Rahim *et al*., 1988; Verma *et al*., 2005). In general most of the annual and

many perennial weeds have been found to be effectively controlled. Weed control may be effected by direct killing of weed seeds by heat, indirect microbial killing of seeds weakened by sublethal heating, killing of seeds stimulated to germinate in the moistened solarized soil, and killing of germinating seeds whose dormancy is broken in the heated soil. Volatiles may also play a role in weed control (Horowitz, 1980; Rubin and Benzamin, 1981).

Increased growth response

Plant growth in solarized infested soil is enhanced as compared to untreated, infested soil as a result of pathogen control but solarization of soil which is apparently free of known pathogens often results in improved plant growth. This could be attributed to increased micro and macro nutrients in soil solution, elimination of minor or unknown pathogens, destruction of phytotoxic substances in the soil, release of growth regulator like substances, and stimulation of mycorrhiza, PGPR, and other beneficial microorganisms. The effect of soil solarization on earthworms population has not received much attention but it is thought that they retreat to lower depths to escape the effect of soil heating. The increased growth response of plants in solarized soil is a well documented phenomenon and has been verified both in green house experiments and under field conditions (Broadbent *et al*, 1977; Katan, 1987; Chen *et al*., 1991; Singh, 2008).

Combining solarization with other methods

Despite the successes achieved with solarization when used singly this method may be usefully aided by combination with other methods of disinfestation. As soil solarization is dependent upon local climatic conditions, sometimes even during conducive periods of the year, local weather conditions will not permit an effective solarization treatment. Therefore, we must come up with integrated uses of solarization in order to increase the predictability of the treatment and thus make it more acceptable to growers. Combining solarization with pesticides, organic amendments, or biocontrol agents improves disease control. Whenever a pathogen is weakened by heating, even reduced dosages might suffice for improved control combining with biocontrol agents, organic amendments, etc.

Low application rates of fungicides, fumigants or herbicides have been successfully combined with soil solarization to achieve better pest control (Hartz *et al*, 1993).Simultaneous application of chemicals and tarping the soil for solarization has been shown to increase the effectiveness of both the methods because of synergism (Ben –Yephet *et al.* 1988; Tjamos, 1984). Reduced doses of metham-sodium (12.5 or 25 ml/m^2) applied singly or in combination with soil solarization synergistically destroyed *V. dahliae* and *F. oxysporum* f.sp. *vasinfectum i*n a naturally infected cotton field. The synergism was attributed to the weakening effect induced by increased soil temperatures along with the toxicity of the chemical. The combination also reduced to one week the time needed to kill sclerotia of *Sclerotinia sclerotiorum* in the top 10 cm of soil in a lettuce field and reduced apothecia production. Carbendazim has shown slower degradation rates after solarization, possibly because of changes in the populations of soil microorganisms after solarization.

Solarization may also be combined with application of crop residues, green and farm yard manures. There is increasing evidence that these materials release volatile compounds in the soil that kill pests and help stimulate the growth of beneficial soil organisms (Deadman *et al*, 2006; Gamliel and Stapleton, 1993).

Soil solarization has also been successfully combined with biological control. The use of *Trichoderma harzianum* with solarization in fields infested with *Rhizoctonia solani* has been shown to improve disease control while delaying the buildup of inoculum (Chet *et al*, 1982). Greenberger *et al*, 1987 concluded that solarized soils are frequently more suppressive and less conducive to certain soil borne pathogens than non-solarized soils. An increase in population of green fluorescent pseudomonads along with an increase of *Penicillium* and *Aspergillus* spp. following solarization has been demonstrated (Stapleton and DeVay, 1982).

Limitations

Solarization involves limitations, difficulties and possible negative effects.

- It is weather dependent and can only be used in regions where the climate is suitable (hot) and the soil is free of crops for about one month or more at a time of tarping with PE sheets. The soil heating effect may be limited on cloudy days. Wind or air movement across the plastic sheet rapidly dissipates the trapped heat. Strong winds may also lift or tear the sheets.
- It is too expensive for some crops and ineffective in the control of certain diseases
- Heat tolerant pathogens might develop after repeated application, though selection for tolerance to lethal agents is not likely to develop with disinfestation methods which are not target specific
- Another possibility would be an increase in pathogen population due to a harmful effect on its antagonists

Future Thrust

Economics: The economic profitability of disease control depends on the additional income obtained and the cost of application. The additional income obtained through solarization far exceeds with high-value crops but with other crops situation may not be the same. There are several possibilities for reducing the cost of mulching: (a) Used polyethylene may be as effective as the new, thus reducing the cost to nearly zero (b) Reusing the polyethylene, providing it is durable (c) If required during the growing season, durable sheets may be used for both solarization and mulch (d) The production of thinner polythene sheets (of an adequate strength) will reduce the amount needed per hectare.

Development in plastic technology: Developments in this field may provide improved and economical mulching materials with greater heating efficiency and increased durability. This may include 1) Biodegradable plastic that decomposes in the natural environment 2) Further development of polyethylene recycling processes 3) Developing economic, novel plastic or other materials more efficient than polythene in trapping solar energy, thus reducing our dependence on

climate and making this available to cooler regions 4) Possibility of plastic material that can be sprayed on the soil, instead of polyethylene mulching, should be explored. At present, biodegradable plastic products available in the market are more expensive than traditional plastics. Their cost needs to be reduced to make them economical.

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Eco-friendly Management of Diseases for Safe Storage and Export of Rice

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Introduction- Rice is a staple food for more than half of the world population and provides 60-70 per cent body calorie intake to the consumers. Paddy occupies 11 percent of world agricultural land and Asia dominates the world in rice production as it accounts for about 90 percent of world's rice area and 91 percent of production. China is the largest producer of paddy accounting 31.76 percent of total world production followed by India. Together these two countries, accounted about half of world paddy area and production. Indonesia (8.52 percent), Bangladesh (5.98 percent), Vietnam (5.44 percent), Thailand (3.91 percent) and Myanmar (3.34 percent) are the other major paddy producing countries.

National scenario- Rice is the most important crop of India and it occupies 23.3 per cent of gross cropped area of the country. Rice contributes 43 per cent of total food grain production and 46 per cent of total cereal production. Acc. to Rice Outlook 2011, during 2011-12 India's rice production estimate was raised by 3.0 million tons to 100.0 million tons. In September, the Government of India's First Advanced Estimate showed a kharif crop of 87.1 million tons, and conditions for the rabi crop have been favourable thus far. This is the largest total rice crop on record for India.

Status of rice export - Basmati rice is known as king of rice and is priced for its characteristic long-grain, subtle aroma and delicious taste. It is one of the major agricultural commodities the country exports every year to earn foreign exchange. Punjab, Haryana and Western Uttar Pradesh are traditional basmati rice growing areas. China is a largest producer of paddy but it consumes nearly all of its annual rice production. India also consumes most of its rice production domestically, but the government does have rice stocks of about 23 million tons, well above the target of about 13 million tons with a bumper harvest in this fall. Agricultural products including rice are the major exports from India to various countries. India is the second largest rice exporter in the world. Indian market spontaneously exports a variety of high quality rice such as basmati, white rice, single boiled rice etc. Rice exporting has a great role in the Indian economy and foreign money exchange. India exports both Basmati and non-Basmati varieties but India's Basmati rice is famous in the world. India exports rice to the different continents like Asia, South Africa, Africa, Europe, North Central America, and Oceana. The varieties, which have good demand in international market, are as follows.

Table. Varieties of International Demand-

Traditional verities	**New varieties**
Basmati 370	Pusa Basmati (IET10364)
Basmati 386	Punjab Basmati - 1 (Bauni Basmati)
Type-3	Haryana Basmati-1 (HKR-228/IET10367)

Taraori Basmati (HBC-19)	Mahi sugandha
Basmati 217	Kasturi (IET-8580)
Ranbir Basmati (IET 11348)	

In addition to a larger crop forecast in October 2011, India has relaxed its export ban on non-basmati rice and is competitively priced on the international market. With Thailand's trading prices largely uncompetitive, India is expected to play a larger role in the global rice market in the upcoming year. India has potential to participate in the International rice trade. There is favorable market access to Indian rice but still the export is highly fluctuating and unsustainable.

Gaps between production and export- In October 2007, Indian government banned the export of non-basmati and 25 per cent broken rice, to strengthen the nation's food security in a time of high inflation and to ensure there was enough stock in the public distribution system to provide subsidised grain to those below the poverty line. Followed by the bumper crop and availability of rice stocks, the government has raised the ban on rice export. India would allow 2 million ton of non-basmati rice and 2 million tons of wheat for export, under open general licenses rather than any sort of quota restriction. India is facing stiff competition in the world market for export of rice. The main thing of suffering of non basmati rice exporting market in the Indian market is countries like Thailand, Pakistan can cultivate this non-basmati rice in low cost. Thailand, the world's largest rice exporter has steadily increased its share of the African market. Thailand is exporting rice to three large African buyers viz.- Nigeria, Senegal and South Africa. Vietnam is the world's second largest supplier of rice. Currently the demand for Vietnamese rice has steeply declined in the International market. The fall in demand is due to good crop in Vietnam's main Asian markets like Indonesia etc. other factors responsible for low export are the following.

- Production of low quality rice and trade inefficiency. Due to some unknown reasons aroma of Indian basmati is reducing.
- The post-harvest losses in both quantity and quality lead to substantial profit gaps among farmers.
- There are considerable knowledge gaps between researchers, extension agents, and farmers.
- Adequate preparations are required to meet the strict compliances of the WTO conditionally in term of quality, pricing and tariff regime etc.

Constraints in rice production- Diseases and insect pests take a heavy toll of rice crop. Neck blast disease in Basmati is becoming increasingly severe. Sheath blight, Helminthosporium leaf spot, BLB, rice tungro virus causes considerable damage at endemic sites. False smut and sheath rot have emerged as new threats. Brown plant hopper, gall midge, yellow stem borer are some of the common insect pests of the high yielding varieties of rice. Disease management largely depends on variety selection and good management. Use of resistant varieties is a popular method to reduce yield loss due to diseases. A good fertilizer management is important for example, rice blast develops better when nitrogen application is high. Plant spacing is also

important to reduce the spread of diseases. Natural enemies of insect pests on rice are of great value in integrated pest management for sustainable rice production with possibility of replacement of need for pesticide input. By deploying effective bioagents like *Trichoderma viride, T. harzianum* and Pseudomonas blast disease can be managed. Some virus diseases such as tungro, can be transmitted by insects (leafhoppers). For this disease vector management is therefore important, mainly by stimulating the natural enemies of these insects or the application of botanical pesticides. An interesting method to prevent disease infestation is the simultaneously planting of several rice varieties in one field.

Post Harvest Losses - A study by the International Rice Research Institute (IRRI) in the Philippines has estimated that from 5 to 16 percent of rice is lost in the harvest process, which includes cutting, handling, threshing, and cleaning. During the postharvest period, another 5 to 21 percent disappears in drying, storage, milling, and processing. Total estimated losses, not counting later losses by retailers and consumers, run from 10 to 37 percent of all rice grown. The Food and Agriculture Organization of the United Nations reports similar estimates of rice loss in Southeast Asia. Due to old and outdated method of paddy milling, improper and inefficient methods of storage of paddy, rice, transport and handling India lost about 9-10% of production. The traditional methods of storage are responsible for about 6% losses and 2-3% rice lost at producer's level. If better methods of processing and storage are adopted, the losses could be reduced to 2 to 3 percent and more food grains could be available to the people.

Table: List of various bioagents used for control of rice diseases.

Disease	Causal organism	Biocontrol agent
Blast	*Pyricularia grisea* (Cooke) Sacc.	*Pseudomonas fluorescens*
Brown spot	*Bipolaris oryzae* (Breda de Haan Shoemaker)	*Pseudomonas sp.* *P. aeruginosa* *Bacillus sp.* *B. subtilis*
Bacterial blight	*Xanthomonas oryzae pv. Oryzae* (Ishiyama Swing et al.	*Bacillus sp.*
Sheath blight	*Rhizoctonia solani* Kuhn	*P. fluorescens* *P. putida* *Bacillus* sp. *B. subtilis* *B. laterosporus* *B. pumilus* *Serratia marcescens* *Pseudomonas* sp. *P. aeruginosa*
Sheath rot	*Sarocladium oryzae* (Sawada) W. Gams & D. Hawksworth	*P. fluorescens* *B. subtilis* *P. aeruginosa* *Pseudomonas* sp.
Stem rot	*Sclerotium oryzae* Cattaneo	*P. fluorescens* *P. aeruginosa* *B. subtilis* *B. pumilus*

Tungro	*Rice tungro virus* Vector0 Nephotettix spp.	*P. fluorescens* (for vector)

Plant pathogens causing post harvest losses- Rice crop grown during *kharif* or wet season is suffering from contaminated with natural mycotoxins. Frequent and heavy rainfall and floods, particularly near harvest, in coastal areas in eastern, southern, and western regions of the country wet the crop and make panicles more prone to invasion by fungi and bacteria. During the wet season, sun drying practiced by most farmers may not adequately reduce the moisture content in grains. Thus, rice grains with moisture content higher than the desired level enter the storage system. As a result invasion by both field and storage fungi takes place. Therefore, mycotoxin-producing moulds could contaminate the grain and produce important quantities of mycotoxins during storage. Mycotoxins are toxic substances produced mostly as secondary metabolites by filamentous fungi that grow on seeds, grains, and feed in the field, or in storage. When ingested, inhaled, or absorbed through skin, mycotoxins may reduce appetite and general performance, and cause sickness or death in humans. It causes severe liver damage and both liver and intestinal cancer in humans. Aflatoxins are the type of mycotoxins, which are derived from the fungi like *Aspergillus flavus, Aspergillus ochraceus, Aspergillus parasiticus* and Penicillium. These fungi are generally regarded as storage fungi, which grow under conditions of relatively high moisture/humidity and causes grain spoilage and mycotoxins (poisonous) production. Mycotoxins are subjected to government regulation in most countries include aflatoxins, fumonisins, ochratoxins, deoxynivalenol, zearalenone, and patulin. Contamination of Aflatoxins occurs at any stage from field to storage, whenever environmental conditions are conducive for fungi. Some important mycotoxin producing fungi are *Fusarium sportrichiella* produces toxin in moist grain which causes Urov disease (Kaschin-Beck disease), toxin in yellow rice produced by *Penicillium inslandium, Penicillium citreovirede, Penicillium atricum, Rhizopus* causes toxic mouldy rice disease, liver damage. In India, presence of 0.1 - 308 µg/kg mycotoxin produced by *Aspergillus flavus and* 0.01 - 65 mg/kg *(Fumonisin) Fusarium verticillioides* was reported by Directorate of rice research. The amount of mycotoxin contamination is different in various states of India, depending upon the temperature, humidity and other farming practices during rice cultivation and storage.

Other problems related to post harvest losses is the presence of Machupo virus which is found in rodent's urine and cause Bolivian hemorrhagic fever.

Management of post harvest losses - Antifungal chemicals have been used for the preservation of stored grains. Health hazards from exposure to toxic chemicals and economic considerations make natural plant extracts ideal alternatives to protect food and feed from fungal contamination. Successful grain storage without using any chemical is a challenging task both for farming community as well as for researchers working exclusively on grain storage.

a). Plant extract- Clove is an extremely safe and consumer-beneficial treatment alternative to prevent storage fungi in rice grains. Clove has been shown to possess antimicrobial activity

against three potent foodborne pathogens, namely *Escherichia coli*, *Staphylococcus aureus*, and *Bacillus cereus*, which are responsible for many health-related problems and clove effectively inhibited the mycelial growth of *A. flavus* and aflatoxin production. Eugenol has been extracted and purified from cloves and from *Ocimum gratissimum*. On rice treated at 2.4 mg eugenol/g of grains, the inoculum of *A. flavus* failed to grow and thus AFB1 biosynthesis on rice was prevented.

b). Biocontrol agents- Several workers evaluated *Trichoderma* isolates against mycelia growth of *Aspergilli* and AFB1 production by *A. flavus*, and found a complete inhibition of growth of *A. flavus* at 15% concentration of *Trichoderma* culture filtrate. Studies on the effect of *Pseudomonas fluorescens* on mycelia growth and AFB1 production by *A. flavus* revealed that culture filtrates of DRPf 002 and DRPf 005 showed maximum growth inhibition (91%–98%) at 15% concentration. *Bacillus subtilis* also effectively inhibit the growth of *A. flavus* and *A. niger.*

c). Physical methods- Rice export-import normally requires fumigation treatment to control grain insects. Conventional treatment either applies methyl bromide or aluminium phosphine. With organic rice trade, two alternative treatments are currently available, vacuumed treatment or carbon dioxide fumigation. The two methods require different packaging materials as vacuumed treatment need non air-exchange bag while fumigation need air-exchange bag.

d). Storage- Different processed rice (i.e. wholegrain, white or parboiled, required different storage conditions. Parboiled rice should can be stored up to one year if keep at lower than 22 degree Celsius and airtight storage. For wholegrain, the maximum storage is two years with airtight storage and temperature is kept between 10-35° C while white rice can be stored up to three years. Relative humidity below 65% is a safe storage condition. Fungi (mold) growth is minimal below 65% relative humidity.

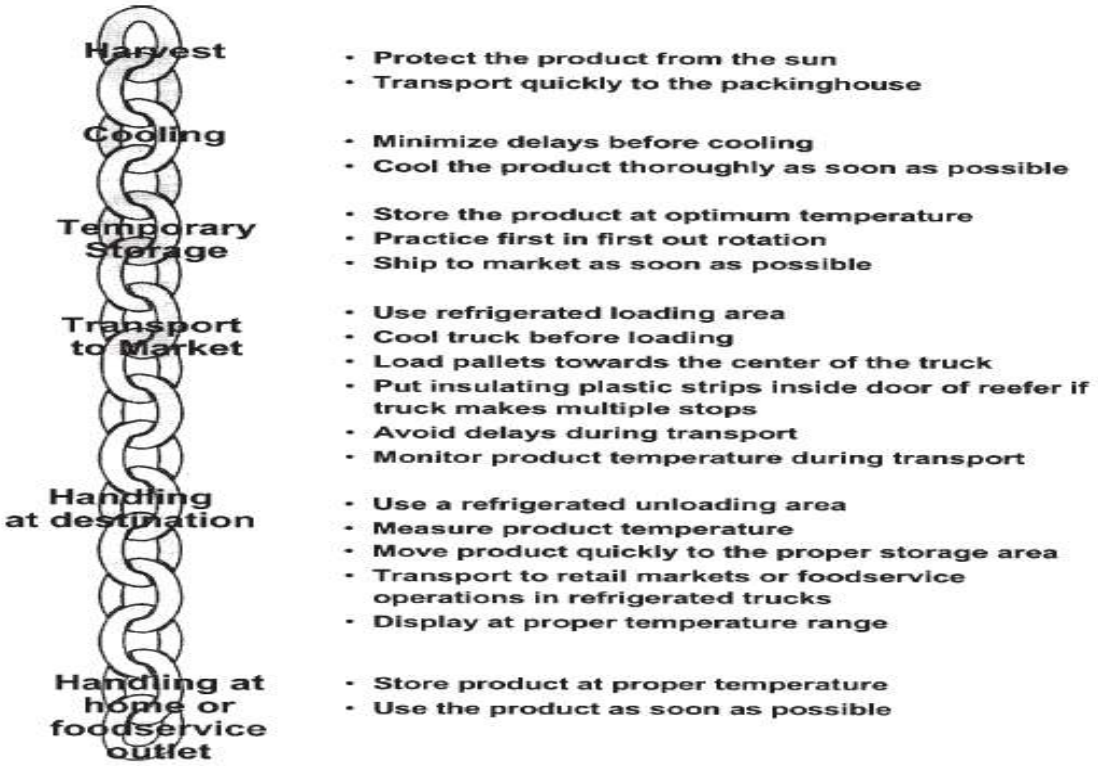
Electronic humidity probes can be inserted into the rice and will read a constant humidity in about 5 minutes. During storage, inspect rice weekly. Test the discharge air for off-odors that generally indicate a rice spoilage problem. Inspect rice on surface of bin during and after major storms to be sure no leaks have developed. Temperature probes are often installed in large storages and are helpful in locating areas with microbial heating and locating temperature differences within the grain caused by heat loss or gain from the outside.

Some technological advances have been made in the area of rice storage techniques and equipment, FAO recommendes use of the small metal silo as a feasible and valuable option for reducing small- and medium-scale rice farmers' food losses. The metal silo for household use varies in capacity from 100 to 4 000 kg. For a family of five people, a silo of 1 tonne capacity can maintain the quality and safety of rice for up to a year, thereby contributing significantly to household food security. A silo of this size costs about US$55 and lasts for between 15 and 20 years. This technology is already improving the socio-economic conditions of agricultural communities.

India has adopted a newly developed Integrated approach - It is based on 3 technologies:

- Electronic insect rap- allows estimation of the number of insects present in rice storage silos.
- Aeration or refrigeration of silos to delay, insect development
- 'Modified atmosphere' with the use of CO_2 or nitrogen gas , again to slow down pest development

Rice post-harvest system: an efficient approach- The rice post-harvest system concept is an efficient modern approach that focuses on preventing post-harvest losses and ensuring the quality and safety of the rice crop during its processing and storage. The system also includes procedures that add value to both primary and secondary rice products, as well as by-products. The rice post-harvest system focuses on both preventing food losses and improving the efficiency of the technologies that are used to add value to rice and its byproducts. It's main concerns should be to: a) improve the capacity in implementing the main rice post-harvest operations so that they become more efficient and ensure a valuable final primary product; b) develop and use processing technology that adds value to secondary and by-products, as well as to primary ones; c) consolidate development of the rice post-harvest agro-industry, not only technically but also commercially, economically, politically, socially and environmentally.



Recommendations to get more yields from basmati varieties- Generally Basmati varieties are more susceptible to get infected from diseases and insect pests of rice. Therefore the following measures may be adopted to manage these problems - To control blast disease, seed treatment should be done before sowing as per recommendation. Sowing of nursery beds should be done timely and as per recommendation. Timely transplanting should be done as per the recommendation to obtain quality Basmati Rice. Transplanting should be done with correct age of

seedling to enable the crop for proper maturity and also for better retention of aroma. Recommended dose of fertilizers should be applied in order to avoid excessive vegetative growth, thereby protecting the crop from lodging. Timely and proper management should be adopted to control the diseases and insect/pests. Proper management of weeds in the field is also essential for effective control of diseases and insect/pests. To control bacterial blight disease, agronomic practices like proper management of water and nitrogenous fertilizers are essential. Harvesting and threshing should be done at proper time with great care to avoid any mixture and also for the better milling recovery.

Conclusion and Future prospects- Improved processing, storage, and direct marketing will help farmers to increase their profits. Effective farmer organizations such as cooperatives can assist farmers in post-harvest processing and marketing. For better grain quality and higher head-rice yield, production and post-production practices have to be improved. These operations must be carried out at the right time to minimize losses and to ensure good grain quality. Many research institutes, including Directorate of Rice Research, India, have carried out research on mycotoxin contamination and developed technologies (*viz*. use of botanicals and microbiologicals) that can significantly reduce contamination, but these technologies are not adopted by the farmers due to lack of awareness. Organization of user groups is vital to successfully introduce such equipment. It is needed to train the (government, non-government, private sector) extension staff and equip them with adequate tools so that they can educate their farmer-clients. Farmers need adequate training and technical support to improve their decision-making capacity.An integrated crop management approach (water, soil fertility/nutrients, weeds/pests/diseases, and post-harvest processing) is vital to maximize the productivity and profitability of rice farmers. All technologies and practices should be used synergistically to help farmers increase and/or maintain grain yields at the same or reduced cost. Improving the quality of milled rice and increasing the recovery of head-rice will enhance farmers' profitability as well as country's revenue by enhancing export.

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Communication Skills in Teaching

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Teaching is a noble profession. It is mission for many people. History is full of prophets and saints who have embraced the role of teacher to influence others. People take up teaching without mental preparation or about the gravity of the role. Role of teacher is not only to pass notes or facts but to stimulate minds to think, analyze and learn.

Teaching is not filling the bucket but lighting the lamp

Students are not empty boxes like buckets. They have experiences, own perception and ways of learning. Thus, a teacher has to know to approach learners at their and with their cooperation.

Hundreds of researches have revealed that more effective teachers

- **Have enthusiasm** for teaching; They love to go to class and meet students. They are emotionally charged and feel happy after teaching.The students also feel pleasure in attending such classes.
- **Are interested in learners & subject**: : They pay attention to students' problems, interact inside and outside of class. They like subject and in turn create an interest for it in students
- **Have expertise:** They have mastery over the content and have comprehensive understanding of theory and practice
- **Give praise & maintain positive environment::** They are postive minded and appreciate good behaviour of students.They always try to create situations in which students perform well
- **Are professional in conduct & appearance:** They take care of their personality, work and time. Students fell inspired to meet them and learn from they words and act
- **Variability:** They use variety of methods and aids to create interest and clarify the subject matter.
- **Fairness/quality of exams: T**hey are not only good teachers but good in evaluating learning. Their examinations are quite balanced in content and testing abilities. They are fair in assessment**.**
- **Preparation:** He plans systematically and manages time efficiently. He is up to date about latest in the subject and resources. **Democratic:** He allows students to actively participate in class room activities. He may even delegate some roles to them.
- **Effective communication skills:** He has command over language. He listens to students and tries to encourage discussion

Teaching is not covering syllabus or passing information. Teachers are hired to influence the minds of the learners. It is indeed quite challenging to motivate and enhance learning among students. It is not enough for the teachers to know and understand the subject t. He has to find

ways and means to make the learners know and understand what he has mastered already. This is quite challenging and calls for more than subject matter knowledge. An effective teacher must master the craft of communication. It is learners who have tol learn at the end of teaching? How can they learn it during the given time? What approach should I select to achieve my outcome? Learners are not empty pots. They have their own experiences and ideas. A teacher must begin where the learner is and take them to the goal. Human mind is like parachute. It works best when it opens. The teacher must do s something to open it. Thus, a teacher must learn a number of skills as described below:

1. Entry behaviour

All the verbal and non-verbal commutation behaviour of teachers communicates something to the students. Teachers must watch out their entry in the classroom. Do you enter carelessly looking at walls, notes and blackboards? Do you consciously smile, look at the students and make a few positive remarks. Be conscious and do not forget to look at your clients and greet them enthusiastically. This builds positive atmosphere.

2. Opening remarks

Students come to your class from hostel or a last class with entirely different subject or an hourly examination. Take time to draw their attention towards the lesson of your class. You may ask one or more students to recapitulate the gist of the least class. How do you open your lecture? Do you start the lesson of the day straight away by writing the topic? Start the class with relevant questions. Giving personal experience and interesting cases relevant to the topic may catch attention of the students. Alternately, students may be asked to recall the last lesson should be clearly spelt out and even written on the board to act as road amp for the students. Let students know exactly what is to be learnt, to prepare them for it.

Various techniques to begin:

- Recall the last class
- Stress importance of today's lesson
- Share a case/personal experience related with the lesson
- Ask them to share something they have known or experienced about the topic
- Discuss a current news item related with topic

It is believed that mostly student are not able to understand the major theme, if teacher has not clearly specified the purpose. So let them know before hand what 4 or5 things they are going to learn today, give them a little overview to crate interest. This will make students attentive and alert about what is to be covered.

3. Designing Lesson

An old German maxim states

"All that is said not listened

All that is listened is not understood

All that is understood is not accepted

All that is accepted is not done”

So there is a large gap between what they hear, understand and do. So the impact of lecture is less in spite of the efforts People understand things better that are logically organized. Logical organization demands organization from simple to complex, empirical to rational, contract to abstract, know to unknown……..

A well-designed lecture should consider the obstacles in communication from learners’ point of view. As a seasoned teacher, you may know their levels of understanding. Ability to organize subject matter logically and in sequence is essential. A teacher must divide his topic into three or four major parts. The parts should be organized in an easily understandable sequence. Each part should be dealt with appropriate introduction, explanation and conclusion so that learners can make sense of it.

Explanation

Explanation is an essential skill that a teacher must have to elaborate,exemplify and make learning easy. Students may not understand terms or processdue to lack of pre-requisite knowledge or awareness about the technical term or a process.A teacher mustask him/herself these questions:.

Did you explain the new terms?

Did you make sure that students know the background information/

Are you sure that the language you are easy to understand for students.

If the answer to these questions is yes,then what strategy do you have to expand the content ? Ability to explain requires explain a difficult term or phenomenon in many alternative ways. Use of examples, evidences and visuals enhance understanding of new concepts.You amy relate with something already known by students.

Use of audiovisual aids

Speaking alone is not enough. What you speak is lost in the air but what you write on the board stays. Plan your board work in advance to put basic essential points on board. Planning visual aids like charts, transparencies or power points beforehand helps to concentrate on explanation. Besides teachers do not have pressure to remember everything. Take care to stand aside and point out the exact on visual.

Use of verbal communication

Speak clearly and loud enough for everyone in the class to hear. Mind your pace of speaking not too fast, not too slow. In fact, follow the same speed as in normal conservation. Become aware if you are in the habit of repeating some words like I mean, you see, let me tell. Avoid such vocal virus or else you will become a laughing.

Use of non-verbal communication

People perceive message mostly through non-verbal communication. Position yourself in full view of the students. Look evenly at both sides; move a little towards students from time to time. Use limited gestures. Use facial expressions to express emotion consistent with the dialogue.

Student's participation

Do students sit passively in your class? Are they taking notes all the time and listen passively to what you speak? It is better to turn the table and their inputs. Sometimes, you may ask the class to summarize what you have spoken in ten minutes. Encourage question answer session at the end of the lecture to clarify doubts.

Use of questions

Questions are important stimulant for learners. Questions make them think different types of questions can be asked for different purpose, as below:

To Check Awareness**:** Easy questions can be asked in between lecture to check deftness of the students. Many students may volunteer to respond and thus, a positive atmosphere is related. It breaks boredom of one way communication.

To Test Knowledge**:** Carefully worded questions may be raised to check understanding.

To Help In Application**:** Practical problems may be given to solve by using relevant theory.

To Develop Critical Thinking Ability**:** Question of high order may check analytical ability of students.

Thus, questions may very form low level to high level depending upon the need. However, it is also important to determine who should be asked.

Ask To The Class**:** Address the question in general to the whole class to see how many people volumes to speak.

Ask To A Group**:** Question may be addressed to a group at the bask, front or side who may be engaged in side-conversation or other diversion.

Ask A Person**:** Question may be addressed to a person to check his, her perform in particular normally questions are addressed to the class.

Handling Students' Questions

Students seldom raise questions but when they do it must be attended to properly. Student's questions are a prize to the teachers. They indicate that the student is attentive and evolved. Teacher may return the question to the class to see of someone knows already. He may rephrase the questions and give class for answer. In the end he may answer himself. Though it is not necessary to respond himself.

Handling Students' Response

Listening is key to responding the response of students should be listened carefully. He, she should be complemented for the part of the response which is right. Student should be given correct answer should be told with explanation. Thus, questioning handling response are important skills to be used purposively.

Ask different types of questions to know the students' progress. Sometimes you may ask simple question to encourage response by many. You can raise the level of question to know the dept of learning. Direct your question to all the students. Do not always ask a particular group only to respond.

Closure

Do not leave the class abruptly Like the opening, closure has a purpose. It must be planned and linked to the overall lecture. Unfortunatly many teachers stop abruptly at the end of fifty minutes or stretch till the nest teacher knocks. The actives to be performed at the close of the lecture are as follow.

1. **Pull out ideas from the lectures.**

   You any ask students to recall what has been presented today. Help them in recalling important materials.

2. **Help in application of the material.**

   It is desirable that students in higher education get to know the practical implications of the materials covered in the class. Problem related with the topic may be discussed.

3. **Achievement of adjectives.**

   You may intricate to the class the facts discussed in the light of the objectives.

4. **Forward planning.**

   In order to prepare students for the next assignment to be completed. You may give a preview of next class and ask students to bring some observations to get them ready.

   - Pull the key points and important explanations together and lead to meaningful conclusion.
   - Ask them to recall key points
   - Tell them the appropriate reference to be consulted and question they think about. You may ask them to come ready for the next lesson.
   - If possible tell them about the next clasd

Teaching should be planned and purposeful. A teacher must show positive orientation towards students through verbal and non-verbal communication. Clearly of expression, simple postures and controlled movement are helpful in conveying meaning.

Disinfestation Protocols for Facilitating Trade in Fruits and Vegetables

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Disinfestation treatments such as fumigation, heat or cold were virtually the sole means by which effective control could be achieved in quarantine to overcome the risk posed by infested produce of fresh horticultural crops early in this century. For almost all pests, and especially for fruit flies, the earliest treatments were replaced for a couple of decades by fumigants (e.g. ethylene dibromide, methyl bromide) and sometimes by residual chemicals (e.g. dimethoate). Consumer preference is now identified clearly as using non-chemical and residue-free physical treatments with heat/ cold, modified atmospheres and irradiation in a large number of countries.

The effect of disinfestation treatment that needs to be imparted depends on how an importing country evaluates the risk of pest in question. It is usually required that its effect should be to the maximum extent attainable to qualify as a quarantine treatment. In this respect, quarantine treatment differs distinctly from the common pest control practices in the field in which the aim is to suppress the pest population below a certain threshold level to avoid economic losses to the crops.

Quarantine Treatments

The three types of quarantine treatments include chemical treatment using fumigants, fungicides, insecticides etc. physical treatments by means of low or high temperatures, vapour heat, high frequency waves, irradiation etc. and the use of chemical and physical treatments in various combinations.

Chemical treatments include fumigation with methyl bromide, aluminium phosphide and hydrogen cyanide and /or carbon dioxide. Fumigation is a method of pesticidal treatment in which fumigant is dosed directly into enclosed spaces such as warehouse, silo, ship hold, container or tent which hold agricultural and forestry products within. Quarantine fumigation is always conducted in accordance with the stipulated standard procedures either at atmospheric pressure or in vacuum that have been worked out for specific insect and plant product at various combinations of time and temperature. A sound knowledge of the physical and chemical properties of the fumigant, susceptibility of pest insects, method of application etc. is essential for these to be used effectively. Other methods for quarantine treatment include chemical sprays, dusting and dipping methods.

In physical treatments, the lethal action on insect pests is obtained by making use of various physical means such as low or high temperature, vapour heat, irradiation, high frequency waves, high pressure etc. These generally require various types of equipments and facilities designed for the purpose and large amount of energy as well. However, it gives consistently high mortality against both insects and pathogenic organisms. Unlike chemical treatments, this does not give rise to residual toxicity to man or environment. Moreover there is a great scope for their

incorporation into commercial processes for agricultural products. Among the examples of thermal treatments is low temperature treatment or cold treatment- CT (± 0°C) against leaf-rollers on apple fruit and fruit flies on citrus fruit; vapour heat treatment- VHT (45°C) against fruit flies on some tropical fruits; hot water dipping (45-80°C) against Narcissus bulb fly and nematodes on flower bulbs, fruit flies on tropical fruits and pathogenic bacteria on roots and rhizomes; dry heat treatment (60-100°C) for seeds infected with microorganisms or for heat tolerant goods infested with khapra beetle. Except for low temperature treatments, these treatments require expensive equipments with high-sensitive thermo-regulators to control treatment conditions precisely.

In case of perishable fruits and vegetables that are susceptible to fumigants and where injuries appear at or around the range of concentrations in which complete mortality of pest insects is attained, complete mortality may be obtained by combined use of the two treatments i.e. placement of low or high thermal treatment either before or after fumigation treatment. Combined use of fumigation and thermal treatment has been known to be effective for apple fruit against codling moth, peach fruit moth, Queensland fruit fly; for apple and pear against light brown apple moth; fruits of apple, pear, apricot, cherry, grape and nectarine against Mediterranean fruit fly. Development of these treatments has opened access to import/ export of banned fruits and vegetables for which no other treatment was available. However they are complicated and require precision thermo-regulators and are expensive, hence, difficult for wider application.

Pre-Requisites for an Effective Quarantine Disinfestation Treatment

Quarantine treatment as a means to prevent dissemination of pests into new territories, must be completely (100%) effective against the target insects or pathogens. Susceptibility of insects to lethal action of treatment differs from one species to another. Depending on the species of insects, it is often extremely difficult to obtain a treatment schedule giving 100% mortality of all stages of pest development. Therefore, the quarantine significance of a pest species should be assessed by pest risk analysis and the level of the effect of treatment to be attained should be determined as appropriate for each species. It may be noted that testing methods and approaches to the development of quarantine treatment differ with the purpose of experiments, the amount of data and information available from past records, the scale of experimentation, etc. If the pest and plant product are clearly defined as targets, it is relatively easier to choose what type of treatment would be suitable. But, when a disinfestation schedule for export products is to be developed, the efficacy of the treatment must meet the level required by the importing country. In case, the treatment aims at the export of banned products, it is always necessary to clear all the phytosanitary conditions required by the importing country.

Therefore, first of all, the quarantine requirements of importing country should be studied. Next, the experimental designs, followed by procurement of tools and equipments are chosen to decide the correct method for complete disinfestation without any injury on treated products.

A successful disinfestation treatment must meet the quarantine requirement for a specific pest without causing significant damage to the quality of the product. The required efficacy needed

to reach the quarantine requirements varies from country to country. For the United States of America the required efficacy has usually been 99.9968% (probit 9) demonstrated at the 95% confidence level with no survivors from 100,000 treated insects (Baker, 1939; Couey and Chew, 1986). For Japan, efficacy is determined as no survivors from a minimum of 30,000 treated pests and New Zealand has a concept of Maximum Pest Limit, currently of allowing five surviving flies in 1,000,000 pieces of fruit for critical fruit fly species such as Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) and Queensland fruit fly, *Bactrocera tryoni* (Floggatt). It is not unusual for a prospective market (e.g. Japan and New Zealand) to require a treatment to be demonstrated repetitively on each cultivar to be imported. Thus, disinfestation treatments are the most important means of obtaining market access where there are pests posing quarantine impediments.

Export to Japan- A Case Study

The disinfestation technology is being developed and exploited specially by the developed countries for taking proper quarantine safeguards eventually to boost their exports of fresh fruits and vegetables. Let us take a case study of Japan to learn as how development of an appropriate disinfestation technology facilitates lifting the import ban on agricultural produce.

Japan is the world's largest net importer of agricultural and food products. Currently, it imports over 60% of its food requirements and this trend is on the increase due to decreasing domestic production and rapidly evolving dietary habits of its people, which continue to drive the imports upwards.

According to the provisions of the Article 7 of the Plant Protection Law (1950), the Japanese Government specifies more than ten pests and prohibits importation of their host commodities because:

1) These pests never existed in Japan and may greatly threaten the domestic forestry and agriculture if they spread in the country, and
2) They are extremely difficult to detect during quarantine inspection

Disinfestation techniques have been worked on for a long time and several improvements have taken place during the past few years. Once an exporting country establishes complete disinfestation technique for the fruits, importation can be permitted provided the treatments have been appropriately developed. In the past, specific imports of fresh fruits were already allowed by the Japanese authorities (Table 1). Appropriate disinfestation protocols in respect of several other fresh fruits and vegetables are currently being developed to ensure lifting of prohibition. For a majority of the developing countries, it is difficult to establish a complete disinfestation procedure on their own and many call on Japan for cooperation.

Table 1: Fresh fruits from countries for which import in Japan was permitted after development of disinfestation protocols

Country/ Region	Fresh fruit	Method of Treatment
Australia	Mango	Vapour heat treatment (VHT)2
	Sweet orange, lemon	Cold treatment (CT)

Canada	Cherry	Methyl Bromide (MB)
China	Melon	Free area confirmed by trapping (FA)
	Litchi	VHT
Colombia	Cherry	MB + CT
France	Yellow pitaya	VHT
Hawaii (U S)	Papaya, mango	VHT
	Apple	MB + CT
India	Mango	VHT
Israel	Papaya, Mango	VHT
	Sweet orange, grapefruit, pomelo	CT
Netherlands	Pepper, tomato, strawberry, cucumber, eggplant, grape, gourd, melon	FA
New Zealand	Cherry, nectarine	MB
	Apple	MB + CT
Philippines	Mango, papaya	VHT
South Africa	Sweet orange, grapefruit, lemon	CT
Swaziland	Sweet orange, grapefruit	CT
Tasmania	Apple	MB
Taiwan	Ponkan, pomelo	CT
	Litchi	VHT
Thailand	Mango, mangosteen	VHT
USA	Cherry, nectarine, plum, walnut	MB
	Apple	CT + MB

Since Japan took a lead in the development and manufacture of the differential pressure method, completely revolutionizing the disinfestation technology, there is a great demand for cooperation from interested exporting countries.

There are four conditions Japan put up for lifting the ban which state that:

(1) The target pest has been eradicated from the infested area

(2) The absence of a pest is confirmed from an area

(3) Some part of the infested area has been designated as a pest-free area and quarantine safeguards maintained

(4) The exporting country has established the method of complete disinfestation

So far, no case of lifting the ban by eradication of target pest has been reported, as this is an extremely difficult task to achieve in reality. Also, it is not ecologically advisable to aim for eradication in areas where the pest has been thriving and is well established or has originated as it

may cause an ecological imbalance and in the process giving rise to new problems.

The second condition for lifting the ban has been reported only in one case of import from Tasmania which is isolated from the mainland Australia by a channel, and an absence of Mediterranean fruit fly is formally confirmed and this area has been designated as a pest free area (PFA). A PFA as defined by International Plant Protection Convention (IPPC) 1996 is "An area, whether all of a country, part of a country, or all or parts of several countries, as identified by the competent authorities, in which a specific pest or disease does not occur" and the guidelines for declaring an area as pest free are given in International Standards for Phytosanitary Measures No-4 (http://www.ippc.org)

The third condition is possible only where natural barriers exist such as climate, which prevents the re-entry of pest such as desert, mountain range and ocean. Also, a strict quarantine should be enforced in such an area to monitor and check the entry of pest in the area.

Hence, most of the cases of lifting the import ban follow the condition number four where the exporting country has developed the technology for complete kill of target pest in the infested countries for specific commodities.

Japan prohibits the importation of fresh fruits and vegetables, which are hosts for fruit flies from the infested areas to prevent invasion by these noxious pests.

According to the Plant Protection Law enforcement regulations of Japan, India cannot export to Japan the following commodities due to the presence of quarantine pests in particular host plants of pests like melon fly and oriental fruit fly (Table 2).

Table 2- Items prohibited for import into Japan from India

Prohibited Items	Quarantine pests
Fresh fruits of citrus, cherry, apricot, fig, strawberry, olive, carambola, plum, tomato, pear, date palm, papaya, loquat, betel nut, grape, peach, apple, litchi, and plants of genera *Bouea, Diospyros, Coffea, Capsicum, Passiflora, Solanum, Zizyphus, Spondias, Psidium, Annona, Garcinia,* plants of the family Sapotaceae and mature banana.	*Bactrocera dorsalis* species complex
Live vines, leaves and fresh fruits of plants of the family Cucurbitaceae, and fresh fruits of kidney bean, pigeon pea, cowpea, red pepper, tomato, egg plant, papaya and plants of the genera *Hylocereus* and *Mangifera.*	Melon fly (*Bactrocera cucurbitae*)
Fresh fruits of apricot, cherry, plum, pear, quince, peach and apple. Fresh fruits and nuts in shell of walnut.	Codling moth (*Cydia pomonella*)
Live vines, leaves, tuberous roots and other underground portions of plants of the genera *Ipomoea, Pharbitis* and *Calystegia*. Live and tuberous roots and other underground portions of cassava.	Sweet potato weevil (*Cylas formicarius*)
Live halms, leaves, tubers and other underground portions of plants of the family Solanaceae.	Synchytrium endobioticum
Live tubers and other underground portions of plants of the genus *Chenopodium* and plants of family Solanaceae.	*Potato cyst nematode* (*Globodera rostochiensis*)
Live tubers and other underground portions of plants of the family Solanaceae.	*White potato cyst nematode* (*Globodera pallida*)

Considerations for Lifting the Import Ban by Japan

The development of disinfestation technology to lift the import ban on prohibited items can be conducted by the exporting country alone or with the technical cooperation of Japanese experts as described below.

1) When the disinfestation technology is developed by the exporting country alone

The most important document to be submitted by the government is the 'Disinfestation Technology Development Test Data', which requires a series of test results and confirmations and takes several years for its preparation which includes determination of the most tolerant stage to the disinfestation technique. The test data is evaluated by the experts for their correctness and security requirement of the Japanese quarantine. The final test on large-scale disinfestation needs to be conducted and confirmed in the presence of a Japanese plant quarantine officer. At any stage, if the data provided are inadequate, additional data would be requested as a reasonable consequence. A 'confirmatory field survey' by the Japan's experts is conducted as the next step, followed by a bilateral meeting between the exporting country and Japan's plant quarantine authority to consider the lifting of ban and a draft of the plant quarantine standards would be prepared by the Ministry of Agriculture, Forestry and Fisheries (MAFF).

The plant quarantine standards would include information on producing districts (with details of pests); enforcement of the disinfestation methodology and inspection in the exporting country; confirmation of the disinfestation by the Japanese plant quarantine officer, method of packing and transportation, safety measures taken to prevent re-infestation by the target pest and any other necessary information from quarantine viewpoint. Thereafter, a public hearing is conducted and amendments made for lifting the ban.

2) When the exporting country develops the disinfestation technology with the cooperation of Japanese experts

If the exporting country intends to develop disinfestation technology with cooperation of Japanese experts, they are required to first file a request with the Ministry of Foreign affairs, which is accepted after approval by the MAFF. Upon acceptance by MAFF, a team of experts would visit the exporting country to examine the necessary matters including the test insect, test commodity, method of disinfestation, equipments available at test site and the protocol of test execution. Based on their report, MAFF decides the requirement of technical cooperation to be extended and a contract for technical cooperation would be drawn up between the two countries.

Next, a team of Japanese experts is dispatched after the required machinery and materials are delivered to the exporting country. The duration of dispatch usually ends after final document of test data is prepared. The last step of 'confirmatory field survey' is usually omitted if Japanese experts take part in the development of disinfestation technology.

Status of Development of Disinfestation Technology for Boosting Exports to Japan

India is the second largest producer of fruits and vegetables, next only to China. The Indian topography and agro-climates are well suited for fruit crops, emphasis is being laid on their

diversification in the last decade. The total production of fruits has increased manifold in the past two decades. Presently, with the emergence of consumer awareness for pesticide residue– free products, protection of environment for a better and healthy living, calorie and protein malnutrition among all sections, quality aspects are receiving great attention alongside quantity demands. Diversification, value addition and export promotional research are the key words in Indian horticulture in the coming years. Similarly, specifications of quality/ codex standard for export of indigenous fruits are being developed.

In India, the export performance of the horticultural sector, especially of fruits and vegetables has been on the increase. Production related technologies to bring quick improvement in production and productivity through short and medium range programmes in fruit crops on genetic resources management, high density planting, bio-fertilizers, organic farming, high density planting, micro irrigation, fertigation, integrated nutrient and pest management are already being undertaken. There is an increased role of pre- and post-harvest management practices against insect pests and diseases which have increased production, quality and shelf life while meeting the IPPC requirements.

However, a lot is yet to be achieved in terms of preparation for increasing the exports of fresh fruits and vegetables. The quarantine requirements for lifting the ban on exportable items need to be studied thoroughly and disinfestation technology developed to meet the exact specifications prescribed by the Japanese Authorities in order to boost exports of fresh fruits and vegetables to Japan. Standards for VHT and CT need to be developed on priority to facilitate the export of Indian mangoes, litchi, sapota, pomegranate and kinnow.

Bulk handling system of tropical fruits, including cold chain, reefer conditions and Controlled Atmosphere storage and post-harvest protocols for sea transport of major fruits are being developed. Disinfestation technology including thermal treatments (vapour heat treatment (VHT), hot water treatment (HWT) and low temperature treatments for export of fresh fruits, being developed, would further promote export promotion.

In order to reduce post-harvest losses at production centres, low cost eco-friendly farm storage structures can play a crucial role. Significant advancement has been made in that direction and some small and medium sized cooling chambers on the principles of evaporative cooling have been devised. Further, refinement of the technology will go a long way. Also, standardization of packing line operations and proper packaging of different commodities urgently needed.

The species of fruit flies commonly reported from India include *Bactrocera dorsalis* (Hendel), *B. cucurbitae* Coquillett, *Carpomyia vesuviana* Costa, *B. correctus*, *B. zonatus* (Saunders), *B. dorsalis* species complex, *B. affinis* from Karnataka and *B. verbascifolia* from Karnataka, Tamil Nadu, Goa and Maharashtra. *B. dorsalis* is a pest of a wide range of fruit crops in the northern areas of Indian subcontinent, *B. zonata* has been recorded from most states located at higher altitudes (*B. dorsalis* being more abundant at lower altitudes) while the Oriental fruit fly, *B. dorsalis* species complex including some 52 species that are found in the whole of

Oriental region.

Thus, the presence of fruit flies both melon and oriental in India necessitate the development of the disinfestation technology using VHT and CT for getting the ban lifted on the export of commodities like fresh fruits of mango, litchi, sapota, kinnow, pomegranate etc. to Japan. Several results of the testing data has already been submitted to the MAFF, Government of Japan for approval and the development of the disinfestation technology is underway for export of fresh fruits to Japan (Lal, 2003). In 2005, approval was granted for export of two varieties of Indian mangoes using VHT to Japan based on the disinfestation technology data.

Problems and Prospects

There are few measures by which the need for disinfestation treatments is eliminated. The four conditions specified by the Japanese authorities for lifting the ban on imports from countries infested with banned pests clearly indicate that the development of disinfestation technology is the most practical and reasonable solution for India. The first i.e. eradication of the target pest from the infested area is not very practical for a country like India as we share a land frontier on three sides with our neighbours and eradication is an extremely difficult task to accomplish seeing the vastness of our country and the range of fruit fly species prevalent. Also, the delicate ecological balance, if disturbed, could lead to problems *de novo*. Since India has several of *B. dorsalis* species and *B. cucurbitae* reported from different agro-ecological areas, it is difficult to confirm the absence of the pest from an area, which is otherwise the second condition for lifting the ban. The third condition that some part of the infested area be designated as a pest-free and quarantine safeguards maintained could be possible through an official control programme provided the cost involved is justified in terms of gain through increased exports. Also, a strict quarantine should be enforced in such an area to monitor and check that the area is maintained pest-free. Hence, the most practical and logical solution for countries like India is establishment of a method of complete disinfestation.

Thus, until tropical fruits are produced in pest-free enclosures and remain free of exposure to pests or until fruits are genetically altered to be resistant to pests, quarantine treatments and methodologies would be indispensable to control pests that attack tropical fruits. The risk of introducing new pests increases as the world population, fruit production and international trade increases and new markets are created to cater to the needs of a growing population of consumers over the globe. Illegal introduction of commodities carried by travelers who fail to heed quarantine requirements are the greatest risk of introduction of new pests to an area. Access for commercial produce under low quarantine security removes much of the temptation. To keep the cost of the tropical fruits low for consumers, quarantine treatments must be affordable. The new treatments designed must be easily adaptable by industry and economical too. The average costs to build facilities that use hot water, vapour heat and irradiation is very high and currently range from US$ 200,000 to 3,000,000 (Sharp and Heather, 2002). Hence, all the factors must be taken into account before venturing into development of such treatments. A thorough market survey and

a realistic cost: benefit analysis must be done prior to undertaking such expensive commercial enterprises.

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Storage Insect Pests of Exportable Crops

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The grains in the storage are spoiled by both extrinsic and intrinsic factors, living organism such as insect, mites and rodents causing heavy losses to the stored products **(Pruthi and Singh, 1950).** In India, an overall post harvest loss due to various agencies every year during storage and handling has been estimated at about 9.33 per cent of which 3.5 per cent are destroyed by stored grain insect pests **(Girish *et al*., 1985).** Insect damage in stored grains and pulses may amount to 10 -40 % in countries where modern technologies have not been introduced (**Shaaya *et al,* 1997).** Food products are attacked from time they are in the field until they are consumed. Direct feeding damage results in reductions in weight, nutritional value, germination and market value. Deterioration and contamination from the presence of Insects results in downgrading of grain and market value due to insect parts, odors, molds and heat damage.

Pest status- Primary Pests- Attack sound grain and the entire larvae and pupa stages are passed inside the grain

Secondary Pests or Scavengers- Eat broken moist and out of condition grain and have some mould growth present eg. Mealworm, Confused flour beetles and Rust red flour beetles etc.

Habitat Areas- Pests can survive and multiple under a number of variable conditions such as: silos ,shops ,farms, Private , houses, bakeries etc.

They can live in dried products such as: Stored grain ,dried fruits, milled and processed cereal products ,sweets ,cheese ,meat and any other dried food, dry ginger, dried fish

Distribution- Stored product pests may be found in all countries around the world, the more humid the greater the numbers.

CHARCTERISTICS

- All pests of stored grain and products have one or more of the following characteristics:
- The ability to reproduce rapidly.
- The ability to feed on dry grain, with the capability of causing serious infestation.
- The ability to migrate in depths of grain.
- The ability to cause severe and extensive damage to grain by rendering it useless by consuming large parts of the whole kernel.
- **Mites:** These are small, translucent soft-bodies creatures, not visible to the naked eye. Mites decreases the germination percentage of cereals and also infest and damage other food stuffs of all kinds. The mites cause direct and indirect damage to stored grains and their products by raising their moisture contents, generating sufficient heat for the growth of infectious bacteria and fungi.
- **Rodents-** The rats cause nuisance in the godowns by cutting the bags , eating the grains and by excreting the faecal matter.

Primary storage insect pests: Insects that can damage sound grains are called as primary storage pests

Common name	Pest	Host
Rice weevil	*Sitophilus oryzae, S. zeamais, S. granarius*	Rice, wheat, sorghum, barley, maize
Khapra beetle,	*Trogoderma granarium*	Cereals, groundnut and pulses
Angoumois grain moth	*Rhyzopertha dominica*	Paddy, maize and wheat
Lesser grain borer	*Sitotroga cerealella*	Rice, wheat and maize
Pulse beetle	*Callosobruchus chinensis, C. maculates*	Pulses, bean and gram
Tamarind/Groundnut Bruchid	*Caryedon serratus*	Ground nut, tamarind and other legumes
Cigarette beetle	*Lasioderma sericorne*	Wheat flour, cereal bran, peanuts, cocoa beans, spices, turmeric, chillies, ginger, stored tobacco, cigarette
Drug store beetle	*Stegobium paniceum*	Turmeric, coriander, ginger, dry vegetable and animal matter
Sweet Potato weevil	*Cylas formicarius*	Sweet Potato
Potato tuber moth	*Pthorimaea operculella*	Potato

Secondary storage insect pest: Insects that damage broken or already damaged grains viz.,

Common name	Pest	Host
Red flour beetle	*Tribolium castaneum*, *Tribolium confusum*	Broken grains, damaged grains, milled products, machinery
Long headed flour beetle	*Latheticus oryzae*	
Saw toothed grain beetle	*Cryptolestus minutas, Laemophloeus pusillus*	Dry fruits ,rice, wheat, maize, cereals and oilseeds
Rice moth	*Corcyra cephalonica*	Cereals, oilseeds nuts, dry fruits, rice and pulse
Fig moth or almond moth	*Ephestia cautella*	
Indian meal moth	*Plodia interpunctella*	Maize, cereals, dry fruits, groundnut, and cereals products

Favorable Factors for Stored Insect Pests Infestation

Moisture and temperature:

The two most important factors influencing the insects, mites and microorganism in store grains are moisture content and temperature of the grain. With favourable conditions heavy infestations rapidly build up. High temperatures above 20 degrees C favour insect development particularly in high humidity above 10%. Moisture is essential to stored grain insects and any increase in the moisture content of the grain can mean an increase insect infestation. Availability and amount of oxygen in the storage is another important factor for the survival of the insect pests.

Source of Infestation During Storage

- Some insects pests like rice weevil, pulse beetle, grain moth come with the grain from the field itself.
- During threshing they may infests the grain and reach unnoticed to the godowns.
- If they are present in the transportation vehicles may infest the during transportation and

reach to the godowns.

- They may be present in the old bags and infests the healthy grains when stored on them.
- They are generally hidden in the cracks and crevices of the walls in the godowns and become active when grains are stored in such godowns.
- The adults may reach to godowns by flying and larvae by moving from the neighbouring places.

Preventive Measures

Cleaning of the godowns: The godowns should be cleaned well and white washed, if possible moisture proof godowns should always be preferred. All the cracks crevices and holes present in the floor, walls, ceiling of the store should be filled up with cement and leveled. The walls of the store may be painted with coal-tar from ground upto the height of 1.5 mater. The dirt, broken infested grains and sweeping of the stores should be removed and burnt before new grain is stored. Fumigation with EDCT mixture for 24hrs@ 10 lt/40cubicmeter of the space. The ceiling and walls of godowns may be sprayed with 0.5% malathion @ 3 lits/sq m.

Cleaning of the bags-Use of new bags as possible. If the old bags are to be used these should be disinfested by the following ways: By dipping them in boiling water for about 15 minutes, by drying them in hot sun heat for about 6 hrs, by fumigating them with EDCT mixture at the rate of 1 lt per 10 bags, by dipping them in 1% malathion solution for 10 minutes. About 20% of the room should be left free between the top layer of the bags and ceiling.

Cleaning of grains and precautions-Bullock carts, trucks or other vehicles used for the transports of grains should be cleaned and washed preferably with phenyl water. The grains should be thoroughly dried before storage, so that it does not have more than 9-10 percent moisture. The clean grain may be brought to the store direct from the thrashing yard. Only one kind of grain should be stored in a store as for possible. If the grains is stored in bags, a layer of bhusa should be sprayed at the floor and bags should be kept 50 cm away from the walls. If the grain is already infested, it should be treated with EDCT mixture @ 15 lit/40q of grain before storing. The grain may be stored with neem seed kernel powder in the ratio 100:1 .

Use of improved storage structures- Some of the improved storage structure developed by different agencies are Pusa bin, Purigade, Patara kothi, Pusa kothi, Pant nagar kuthla, Hapur bin etc. Indoor bins groups includes domestic designs of metal bins,gharelu thekka, pucca kothi and welded wire mesh bun and RCC ring bin. Outer bins includes flat bottom metal bins, hopper bottom metal bins , composite bins and R.B. bins.

Curative Methods

Generally fumigants are used for both preventive and curative measures against insect pests of stored grains. Most of the fumigants affect germination especially at higher moisture content. Considering the ill effects of pesticides there is a need for development of alternative strategies like use of plant material, animal origin material, inert dusts, regulation in temperature and humidity so that seed quality , germination of seeds and consumption could not be affected.

1. Ecological control- Insect population in stores can be checked through temperature and grain moisture regulation and controlled atmosphere. Temperature below 14C results in death particularly of immature stages of almost all insect-pests. Most of the stored grain insect die at 50 to 60C within a period of 10-20 minutes so grain heating can be done.

Solar bed: Exposure of grains on solar bed for 15 minutes on sunny days before storage also at regular interval of 60 days and 120 days is very effective to check insect infestation. Grains stored at around 10% moisture content escape from the attack of insects. The exposure of period of 24h to solar energy in black and blue coloured polythene bags was most effective to reduce infestation and adult emergence and to cause adult mortality of the insects.(**Jakhar *et al*,2006).**

Hermetic storage – About 9.0 to 9.5% CO_2 in air is lethal to all insects. In this storage oxygen level reduces below 1% and CO_2 automatically increases which is lethal to all stages of insects.

2. Mechanical control-Use of traps is a relatively new method of detecting as well as controlling insects in bulk. These can improve the effectiveness of insecticides applications and sometimes reduce the use of more toxic, compounds Three types of pit fall traps a) 12cm dia. and 9 cm slope b) 9cm dia. and 7cm slope c). 15cm dia. and 12cm slope developed by Tamil Nadu Agricultural University for trapping of beetles infesting pulses are good indicators for detection of infestation and reducing the population of beetles after being trapped. Pit fall trap can be placed in metal bins, small tin containers, utensils and plastic bucket used for storage of any kind of pulses. Sticky traps and artificial crevices can also be used to detect infestation of the beetles in the storage structure.

3. Biological control-Bacteria such as *Bacillus thuringiensis* (B.t.) registered as protectant for use on grains in USA the larve of Indian meal moth and Almond moth, showed high levels of susceptibility to Bt.

4. Plants and other non-toxic grain protectants- The different plant products like vegetable oils, neem oil, neem leaf and kernel powders etc were found effective against many stored insect pests. **(Ansari *et al* 2004, Yadav and Bhargava, 2006, Meena *et al* 2010).** Inert material like clays, and, paddy husk ash and wood ash, minerals, dolomite, rock phosphate, common salt(10g/kg grains.) , synthetic silica and diatomaceous earth were found effective against many stored beetles and moths.(**Matti and Awaknavar ,2009)**

5. Effect of animal origin products on insect infestation- The effect of cow dung cake ash on the oviposition of *C. maculates* on pigeon pea seeds upto 105 days with maximum germination of 95.4%. **(Sangwan *et al* 2005 and Tiwari 2006)**. Biogas (methane and carbondioxide) was successfully used in the control of stored grain insect pests such as *Rhizopertha dominica, Sitotroga cerealella, Corcyra cephalonica* infesting paddy which was carried out in 100 kg capacity of PVC bins over a period of 8 months. It was observed that it had no any adverse effect on seed germination of paddy **(Yadav and Mahla, 2005, Sharma *et al*, 2008).**

6. Chemical Control-When attack of stored grain insects is in progress in the godown, any one of the following fumigants may be used to check them. EDCT mixture @ 0.5 lit/metric tons of grains

and EDB ampules 3 ml @ 1/q of grain. Aluminium phosphide tablets @ 1/metric ton of grain or 7 tblets per 28 cu.m. of space.

7. Legal control- The quarantine measures should be followed during the export and import of the grains or any other stored material to restrict the entry of any infestation. Fumigation must be done at the ports of entry if any pest infestation is noticed.

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Implications of Sanitary and Phytosanitary Agreement on Agricultural Trade in India

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The establishment of the WTO in 1995 has provided unlimited opportunities for international trade of agricultural products. History has witnessed the devastating effects resulting from diseases and pests introduced along with the international movement of planting materials, agricultural produce and products. It is only recently that legal standards came up in the form of Sanitary and Phytosanitary (SPS) Measures for regulating the international trade. The WTO Agreement on the Application of SPS measures concerns the application of food safety and animal and plant health regulations. It recognizes government's rights to take SPS measures but stipulates that they must be based on science, should be applied only to the extent necessary to protect human, animal or plant life or health and should not arbitrarily or unjustifiably discriminate between members where identical or similar conditions prevail (http://www.wto.org, Khetarpal and Gupta, 2002).

The SPS Agreement aims to overcome health-related impediments of plants and animals to market access by encouraging the "establishment, recognition and application of common SPS measures by different Members". The primary incentive for the use of common international norms is that these provide the necessary health protection based on scientific evidence and improve trade flow at the same time.

SPS measures are defined as any measure applied within the territory of the Member State:

a) to protect animal or plant life or health from risks arising from the entry, establishment or spread of pests, diseases, disease- carrying/ causing organisms;
b) to protect human or animal life or health from risks arising from additives, contaminants, toxins or disease causing organisms in food, beverages or foodstuffs;
c) to protect human life or health from risks arising from diseases carried by animals, plants or their products, or from the entry, establishment /spread of pests; or
d) to prevent or limit other damage from the entry, establishment or spread of pests.

The SPS Agreement explicitly refers to three standard-setting international organizations commonly called as the 'three sisters' whose activities are considered to be particularly relevant to its objectives: the Food and Agriculture Organization (FAO)/ World Health Organization (WHO) Codex Alimentarius Commission, the Office International des Epizooties, and the international and regional organizations operating within the framework of the FAO International Plant Protection Convention (IPPC). They are observers and important contributors to SPS committee meetings. They are also called in as experts to give advice to WTO dispute settlement panels. For matters not covered by the above organizations, appropriate standards, guidelines and recommendations are promulgated by other relevant international organizations open for membership to all members of WTO, as identified by the SPS Committee. The IPPCs provide guidelines on pest prevention,

detection and eradication and till date, thirty four standards have been developed and few others are at different stages of development.

Implementation of SPS Measures

Ever since the SPS Agreement has come into being most of the countries are using this instrument for international trade. India is a classical example of a developing country preparing for the challenges being encountered in WTO regime. The negotiations for import of soybean and wheat from USA and export of mango and grape to China are based on Pest Risk Analysis (PRA) and identification of Pest Free Areas (PFA) which are the requirements as per Article 5 & 6 for facilitating trade among member countries under the Agreement. In case of soybean import the qualitative pathway-initiated PRA was developed by the US itself on the basis of the list of the important quarantine pests of soybean submitted to them by Government of India.

The establishment of the World Trade Organization (WTO) in 1995 has provided unlimited opportunities for international trade of horticultural products with legal standards in the form of Agreement on Application of Sanitary and Phytosanitary (SPS) Measures for effective regulation. As the SPS issues now play an important role in trade negotiations, it further implies that countries need to strengthen their plant health related services to facilitate import/ export. The various policies and regulatory measures related to phytosanitation aspects of the country has been recently reviewed (Khetarpal and Gupta, 2006).

The SPS measures are used as tools for safeguarding the national interests. Quarantine is the principle phytosanitary measure playing a key role in pest-free trade of horticultural commodities. The phytosanitary issues broadly include the pest-free production, pest risk analysis, authentic detection of pests and suitable disinfestation technologies to meet the requirements of importing countries to promote trade. These along with adoption of pre- and post-harvest pest management practices to increase production, quality and shelf life would boost the horticultural trade (Rajan *et al.*, 2005).

Role of Plant Quarantine in Agricultural Trade

Exchange of agricultural material has resulted in enormous losses due to the inadvertent introduction of exotic pests along with their planting material. The Irish potato famine of 1845 is well known example of total devastation of potato crop caused by late blight fungus (*Phytophthora infestants*) introduced from Central America. Potato being a staple food for the people, caused starvation and mass migration of Irish people to America and other parts of the world. Likewise, the vine industry of France in the middle of 19th century was virtually destroyed due to introduction of powdery mildew (*Uncinula necator*) and downy mildew (*Plasmopara viticola*) of grapes from America. The movement of the devastating stored grain pest Khapra beetle (*Trogoderma granarium*) is a classical example of movement of pest in international trade. Its introduction was recorded in USA, Italy and Zimbabwe in 1940s and the pest is still spreading continuously in international trade.

In India too, many pests were introduced on horticultural crops, which have since become

serious pests and continue to cause damage year after year. The San Jose scale (*Quadraspidiotus perniciosus*), a pest of apple was introduced into India in 1930s and causes enormous losses in apple orchards in Himachal Pradesh. The wooly aphid (*Eriosoma lanigerum*), a serious pest of apple also introduced into India causes substantial losses in apple growing states of north India. The fluted scale *(Icerya purchasi*), a serious pest of citrus and native of Australia was introduced into India before 1928 from Sri Lanka probably on wattles (*Acacia* sp.) to later become a serious pest on citrus in south India. A large-scale campaign was organized in south India from 1946 to 1950 to check the spread of this pest. Among the other more economically important plant disease introductions in fruit crops is bunchy top virus of banana from Sri Lanka in 1940, which has since spread widely in almost all banana growing regions like south India, Orissa, Bihar, West Bengal, Assam and even in north India. The mosaic disease of banana, an introduced disease initially confined to Gujarat and Maharashtra has now spread to other banana growing regions in the country (Sharma, 1992). All these examples clearly demonstrate that imported seed/ planting material, especially bulk imports, may result in introduction and establishment of quarantine pests into new areas, which may severely damage crop production and the economy of a nation.

National Regulatory Mechanism

With a view to restrict the entry of exotic pests and weeds through regulation of imports, the Government of India presently works under the Plant Quarantine (Regulation of Import into India) Order 2003 which forms the basis of functioning of the Directorate of Plant Protection, Quarantine and Storage (DPPQS) under Department of Agriculture which is entrusted with the implementation of plant quarantine regulations. It is the national agency responsible for implementation of quarantine policies and standards targeted to prevent the introduction, establishment and spread of quarantine pests. It operates through a network of quarantine stations located in different parts of the country that act as entry and exit points. After the coming of the WTO Agreements in 1995, import of agricultural commodities is being allowed more freely. This has led to greater chances of introduction of new pests and diseases into the country and is threatening our biosecurity (Khetarpal and Gupta, 2007 and 2008). Under this Order, the need for incorporation of 'Additional/ Special Declarations' for freedom of import commodities from quarantine pests, on the basis of standardized pest risk analysis (PRA), is a mandatory requirement under the SPS Agreement of WTO, particularly for seed/ planting materials.

The agricultural material being imported into India are a) bulk consignments for consumption/ planting materials for sowing/ planting, and b) samples of germplasm in small quantities for research purposes. The Plant Quarantine Stations, numbering 35, under the DPPQS undertake quarantine processing and clearance of consignments of the first category. National Bureau of Plant Genetic Resources (NBPGR), New Delhi, the nodal institution for germplasm exchange, collection, evaluation and conservation, has been empowered under legislation to handle quarantine processing of germplasm and transgenic planting material being imported for

research in the country by both public and private sectors (Khetarpal *et al*., 2006).

The Indian Government is trying to gear up its activities to meet the challenges posed by the Agreement. This is a need of the hour for all developing countries despite it being a gigantic task. It involves harmonization of Acts, developing guidelines and quality standards to international norms and so also development of technical and scientific manpower and infrastructure. Since decisions under SPS Agreement are required to have a sound scientific basis, it is essential to first understand the critical gaps in the field of plant protection so that areas of research can be properly identified. The researchable issues for efficient implementation of SPS measures thus needs to be identified, highlighted and addressed so that the scientific and technical arguments that are the back bone of policies is strengthened. This, however, would be a regular exercise to be done under WTO regime so that research output can be advantageous to trade.

Implications of SPS Agreement on Agricultural Trade

The SPS Agreement concerns the application of food safety and animal and plant health regulations. It recognizes government's rights to take SPS measures but stipulates that they must be based on science, should be applied only to the extent necessary to protect human, animal or plant life or health and should not arbitrarily or unjustifiably discriminate between member countries where identical or similar conditions prevail (http://www.wto.org, Khetarpal and Gupta, 2002). It aims to overcome health-related impediments of plants and animals to market access by encouraging the establishment, recognition and application of common SPS measures by different Members.

Prior to the establishment of WTO, governments on a voluntary basis could adopt international standards, guidelines, recommendations and other advisory texts. Although these norms remain voluntary, the SPS Agreement has conferred a new status upon them. A WTO Member adopting such norms is presumed to be in full compliance with the SPS Agreement. These are aimed to improve the phytosanitary situation for member countries and the enforcement of SPS measures would result in minimizing the risk of introduction of noxious pests. The basis of allowing import of agricultural commodities including horticultural material depends on appropriate level of protection or acceptable level of protection (ALP) of the member countries. Where the risk of pest introduction is above the ALP, the importing country may ask for application of disinfestation measures to reduce the risks.

Prior to export, all countries are required to make suitable arrangements for inspection, treatment and issuance of PC after thorough examination of the planting material. The certificate needs to be issued by the authority of the exporting country. ISPM 12 developed by IPPC gives guidelines for issuing PC which is internationally acceptable to secure common and reciprocal action to prohibit introduction and spread of exotic pests. The purpose is to certify that the exported product meets the quarantine requirements of the importing country.

Most countries have well-organized import regulations, requiring import permits issued by the plant protection service of the importing country which spells out the conditions under which

the importer may receive a desired plant material. The document signifies that the material needs to be inspected and declared free from certain important pests of significance to the importing country.

The above-mentioned procedure is followed during trade of all agricultural commodities including horticultural material. However, as far as India is concerned, a lot is yet to be achieved in terms of preparation for increasing the exports of horticultural material. The quarantine requirements for lifting the ban on exportable items need to be studied thoroughly and disinfestation technology developed to meet the exact specifications prescribed by the importing countries in order to boost exports of fresh fruits and vegetables. Standards need to be developed on priority to facilitate the export of several exportable fruits like mangoes, litchi, sapota, pomegranate, and other horticultural crops.

SPS Issues Influencing Trade in Agricultural Crops

The major issues for the import and export of horticultural crops/ products include those related to pest risk analysis, pest status, designating areas free from pests, maximum permissible limits of pesticide residues, certification, development of disinfestation treatments, biosafety in case of transgenic crops and export promotional research.

Pest Risk Analysis: Risk analysis is a systematic way of gathering, evaluating, recording and disseminating information leading to recommendations of an action. In SPS and IPPC pest risk analysis consists of two components (a) the probability that the pest will be carried on the product being exported, survive during transport to the importing country and establish in the importing country. (b) the potential impact of this pest in the importing county, depending upon presence of hosts and prevailing climatic conditions (Gupta *et al.*, 2002).

The risk analysis process consists of three stages (a) Stage 1- Initiation involves identification of the risk pathways and pests that are to be analyzed (b) Stage 2- Pest Risk Assessment involves an estimate of the risk based on the probability of entry and establishment of the pest and the potential impact of the pest should it establish and (c) Stage 3- Pest Risk Management identifies appropriate risk management measures to reduce the pest risk to the acceptable level of risk. The procedures to be followed for risk analysis of pests are mentioned in the ISPM-11 (Pest Risk Analysis for Quarantine Pests) and ISPM-21 (Pest Risk Analysis for Regulated Non-quarantine Pests). The standards of PRA ensure that all restrictions in trade are based on the assessment of authentic risks and are not arbitrary or discriminate against any exporting countries with the same pest status. In case the pathway of pest entry is vegetative material being imported for planting, quarantine regulations need to be more stringent. For instance, import of potato stocks in the form of true potato seeds/ *in vitro* plants/ micro/ mini/ seed tubers are prohibited from South America under the PQ Order, 2003. This is mainly because of the presence of large number of destructive pests not yet reported from India and only germplasm import is allowed after strict quarantine.

Pest Status: An important criterion for carrying out risk analysis is information about the pest

status of both the exporting and the importing country. Information on the pest status of the exporting country is needed to determine that listed pests that might move along with the commodity exported.

The ISPM 8 on 'Determination of Pest Status in an Area' provides the procedure of recording information about a pest and categorization of its status. The standard allows for claims of pest absence based on the lack of records rather than specific surveys but all claims should be supported by published documents. Guidelines on general and specific surveillance are given under ISPM-6 (Guidelines for Surveillance) giving details on good surveillance practice, technical requirements for diagnostic services and record keeping.

Pest free areas for growing agricultural crops: The easiest way of management of pest risk is by importing produce from an area that has been declared as pest-free. The ISPM 4 (Requirements for the Establishment of Pest Free Areas) provides guidelines on the establishment and maintenance of pest free areas (PFA) which may consist of an entire country or an uninfected part of a country situated within a generally infested area. The term PFA is applicable for an area that has been found completely free of a pest or is made free through specific actions and is protected from infestation or re-infestation. It does not imply an absolute absence of all pests. It is usually delimited by recognizable geographical or political boundaries. Much of the advantage depends upon the biology and spread potential of the quarantine pest in question. The ISPM 10 provides guidance for situations where the pest freedom is based on much smaller areas for example, a single field/ orchard or a single glass house. The horticultural exports from Israel and Japan are now mainly based on production from certified pest-free polyhouses.

Maximum permissible limits of pesticide residues: Since horticultural produce are traded in fresh form, pesticide residues are undesirable as they are potential health hazards. The hazards can, however, be minimized if the level of toxic residues are kept within permissible limits / considered safe i.e. maximum residue limits (MRL). The Codex Alimentarius Commission has fixed MRL or tolerance limits of various pesticides on agricultural produce. These limits are based on extensive toxicological studies and supervised field trials. MRLs are very important in international trade as excessive residues are not accepted by importing countries and act as non-tariff barriers. Plant protection schedules of exportable horticultural crops that are found effective and safe from the point of view of toxic pesticide residues are being developed taking into consideration the pre-harvest waiting periods for safe use of pesticides.

Application of pesticides in the field is a phytosanitary requirement to manage the pest. However, the residue left by these applications is a sanitary issue which needs to be below the MRLs prescribed by the Codex commission. Thus, the sanitary and phytosanitary requirements are closely interlinked and cannot be treated as mutually exclusive, though there are different agencies dealing with them.

Disinfestation treatments: If the horticultural produce is not from a PFA, one way of phytosanitary management is by making the exportable commodity pest-free through certain

treatments. It could be a single treatment or a combination of treatments to reduce the risk to the ALP. In this case orchards need to be regularly examined, frequently sprayed with pesticides and the exportable commodity/ the fruits suitably treated before packaging. Temperature and moisture conditions need to be duly maintained during transit and if need be further appropriate precautions taken in the country of import reduces the risk level. The ISPM 14 -*The Use of Integrated Measure in a Systems Approach for Pest Risk Management* provides the guidelines for use of combination of treatments/ system approach for treatments to eradicate pests on the exportable commodities. Post harvest treatments need to be carried out to mitigate the risk where inspection alone is not adequate. Typical treatments to the horticultural commodities are cold & high temperature, hot air/ water, irradiation, fumigation and /or combinations thereof.

The ban imposed by many countries like Japan and USA on import of mangoes from India due to presence of fruit flies and mango stone weevils emphasizes the need to develop disinfestation technologies as per the norms acceptable to the importers. These countries accept consignments only after disinfestation treatments with hot water or vapour heat treatment (VHT). Hence, apart from quality of fruit, shelf life and other export requirements development of quarantine treatment as per requirements of the importing country is the main constraint in mango export (Gupta and Khetarpal, 2005).

Post-harvest deterioration of agricultural crops: Post-harvest rotting caused by fungal infection and other secondary pests carried over in incipient form from the field gets flared up under improper storage conditions. This is an example of a phytosanitary issue turning into a sanitary issue in case the fungus produces toxins in the infected fruit. A clear-cut interlinking between the sanitary and phytosanitary issues is observed in such cases. Post-harvest decay in guava caused by *Botryodiplodia theobromae, Colletotrichum gloeosporioides, Pestalotiopsis versicolor* and *Phomopsis psidii* is one such example in literature (CAB *International,* 2007).

Biosafety: Increasing use of biotechnology and production of transgenic crop varieties requires development and implementation of biosafety norms. In addition to the regular risk assessment required for safe trade in horticultural crops, biosafety aspects also need to be looked into (Khetarpal, 2004). The ISPM- 11 has recently been revised to include analysis for environmental risks and risks from living modified organism (LMOs). Trade problems arise when countries have different regulations regarding the testing and approval procedures taking into account all biosafety issues. Cartagena Protocol covers the trans-boundary movement, transit and use of all LMOs that might have adverse effects on the conservation and sustainable use of biological diversity, taking into account risks to human health and SPS Agreement recognizes Cartagena protocol on biosafety related issues. The protocol requires that decisions on proposed imports be based on risk assessments. The transgenic horticultural crops developed so far are tomato, sugarbeet, papaya and potato. The traits for which they have been or are being developed include insect resistance, viral disease tolerance, quality improvement and stress resistance. Several countries of European Union and Japan, still maintain a conservative approach as far as trade in

transgenic material is concerned.

Trade promotional research: There is a need for development of bulk handling system of tropical fruits, including cold chain, Reefer conditions and Controlled Atmosphere (CA) storage and post harvest protocols for shipment of major fruits like banana, mango, litchi, sapota, kinnow, pomogranate and others. Disinfestation technology including thermal treatments (vapour heat treatment (VHT), hot water treatment (HWT) and low temperature treatments for export of fresh fruits would help in export promotion. For instance, the export of grapes to China has recently been allowed, after adopting cold treatment for disinfestation against fruit fly *Bactrocera dorsalis* and fungus *Phoma glomerata*. Organic farming and residue free integrated pest management (IPM) technology are other important areas of research.

In order to reduce post-harvest losses at production sites, low cost eco-friendly farm storage structures can play a crucial role. Significant advancement has been made in that direction and some small and medium sized cooling chambers on the principles of evaporative cooling have been devised but need further refinement of the technology. Also, standardization of packing line operations and proper packaging of different commodities are of urgent need (ISPM- 15- *Guidelines for regulating wood packaging material in international trade*). Also, there is a need to reprioritize research projects based on critical gaps identified to meet the requirement for export and import.

Upgradation of national sanitary and phytosanitary regulatory system: Efforts are needed to streamline our regulations as per international norms to enhance our agricultural trade. Some of the areas that need immediate attention are strengthening of PRA unit, establishment of a nationally coordinated plant pest surveillance system, establishment of diagnostic facilities for detection and identification of exotic pests, detection of GM contamination in undeclared samples, strengthening domestic quarantine/ emergency services to check spread of introduced pests into newer areas and develop quality assurance machinery including traceability mechanism (like Hazard Analysis and Critical Control Point [HACCP] certification) of farm produce to ensure compliance with SPS requirements of the importing country.

To accomplish the above mentioned tasks, technical assistance provided by the WTO Secretariat to developing and least developed country members for implementation of the SPS Agreement can be sought. Possibility of bilateral cooperation with international organizations, especially with the three standard-setting organizations, in the form of scientific advice/ setting up national inspection services/ investments in laboratory infrastructure needs to be explored.

Conclusions

The liberalized trade policies of the governments / WTO have put a big responsibility on quarantine personnel for properly achieving their objectives of excluding the exotic pests or to carry out eradicative measures. The risk of pest introduction and means to stop the establishment of these pests into new areas continues to be a major concern of phytosanitary/ quarantine officials for which a critical appraisal has been done recently for the Indian scenario (Khetarpal.

2004). Unless proper phytosanitary measures are taken, pests could get transported all over the globe, become established in new areas and devastate fruits and vegetable production.

However, on the other hand there are tremendous opportunities to the growers involved in export of fruits or planting materials to boost the national economy if they meet the international quality standards and overcome phytosanitary constraints. The recent lifting of ban by China and Australia on imports of mango and grapes from India was achieved by proper implementation of regulations and development of acceptable disinfestation techniques, which is a good beginning in this direction.

The Agricultural and Processed Food Products Export Development Authority (APEDA) has set up about 60 export processing zones in the country so far. A mechanism needs to be developed through a network system (1) for adoption of these zones by researchers for undertaking export promotional research so that exports from these zones meet international sanitary and phytosanitary standards (2) for production and export from pest free areas (3) for monitoring mechanism needed for maintenance of pest free status of these areas.

With an increase in the agricultural production over the last fifty years, India needs to now focus its attention on diversification and export promotion. Likewise, specifications of quality/ codex standards for export of indigenous fruits also need to be developed. Active participation by India in IPPC, Codex Alimentarius meetings to negotiate for reasonable standards would also give the necessary push to trade in agricultural material. All this is possible if the government agencies involved in sanitary and phytosanitary issues work in complete coordination with each other, to achieve international standards which would ultimately boost exports of agricultural commodities.

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Standard Operating Procedures for Export Inspection and Phytosanitary Certification of Plants / Plant Products and other Regulated Articles

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Introduction- Since India attained independence, the nation has been applying a thoroughly need based strategy in the agriculture sector eventually intensifying the same after mid sixties with a chief focus on meeting the nutrition needs of the country's exploding population so as to make the nation self reliant with respect to food production. India has made rapid strides from food shortages and import to self-sufficiency and exports, from subsistence farming to intensive and technology led cultivation. Today, India is the front ranking producer of many crops in the world. Largest producer of milk, jute, tea and pulses, have second largest cattle population (with 281million animals in 2011). India is second largest producer of rice, wheat, sugarcane, cotton, groundnuts, fruit and vegetable (accounting for 10.9% and 8.6% of the world fruit and vegetable production respectively) and second largest producer and consumer of silk (producing 77,000 million tons in 2005). The notable features of the Indian agriculture industry are: its export prospects, competitive pricing and International standards. The Agricultural and processed Food Products Export Development Authority (APEDA) has stated that India's exports of fruits, vegetables, cereals and processed food products was worth US$ 1.14billion during April May 2010-11 period. Goverment has set target to raise India's share in International export. India is having competitive advantage due to its diverse agro climatic conditions with production of fifty different crops, sufficiency of Inputs and reasonable labour costs. Strategies and Initiatives for Promotion of Exports are as follows:

- Improvement and maintenance of quality.
- Consonance with International Standards.
- Strengthening of Infrastructure.
- Identification of niche products and markets.

Indian agricultural products like marine products, rice, wheat, condiments and spices, cashew, tea, coffee, castor, jute, fruits and vegetables like Onions, Mango, Grapes, Banana, Tomato, Potato, Litchi, etc have potential for International export. The major destinations to which Indian agricultural products are exported includes USA, China, UAE, Japan, UK, Bangladesh, Malaysia, Sri Lanka, Pakistan, Nepal, Netherlands and Germany. Floriculture products, rice, wheat, dry fruits, fresh vegetables and fruits, vegetable and fruit seeds and animal products exported to these countries. Despite the commendable growth in agriculture and agriculture products, there has been a fall in the total volume of exports of agriculture products from India since 2004 to 2009 from 12.7% to 10.23%. Food safety and agricultural health are challenges for participation in international trade; these could be overcome by knowledge of Sanitary and Phytosanitary measures (SPS) and International standards for export.

SPS agreement- The Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) is one of the multilateral trade agreements, which all members of the World Trade Organization (WTO) are committed to observe. With the signing of WTO Agreement on Agriculture in 1994, India, alongwith 119 other member countries have to implement the agreement. There are various obligations of agreement which includes reform trade in agriculture and provide the basis for market-oriented policies on agriculture, it is related to the aspects of market access and domestic support, export competition/subsidies, Sanitary and phytosanitary measures (SPS), and Trade Related Intellectual Property Rights (TRIPS). Among technical regulations and standards, sanitary and phytosanitary (SPS) regulations occupy a particularly relevant place in the regulators' agenda, because of their primary aim of protecting citizens from everyday food hazards. This has become a virtual minefield for trade policy-makers as national differences in risk perceptions and tolerance can be manipulated or exploited to protect domestic industry from international competition. These regulations are generally considered as "technical barriers to trade" which can be defined as "regulations and standards governing the sale of products into national markets that have as their prima facie objective the correction of market inefficiencies stemming from externalities associated with the production, distribution, and consumption of these products".

Sanitary and Phytosanitary (SPS) Standards - Technically, SPS are a subset of regulations that specifically aim to protect human, plant and animal health. Sanitary measures are those related to human or animal health, and phytosanitary measures deal with plant health. The protection of fish and wild fauna, forests and wild flora are included in this definition while the protection, for example of the environment *per se* and animal welfare are excluded. This broad definition is narrowed by the WTO in the SPS Agreement as any measures applied to the following:

- Protect human or animal life from risks arising from additives, contaminants, toxins or disease-causing organisms in their food.
- Protect human health and life from plant or animal-carried diseases.
- Protect animal or plant life from the introduction of pests, diseases or disease causing organisms.
- Protect a country from damage caused by the entry, establishment or spread of pests.

One of the main problems related to SPSMs, and regulations in general, is that even "well-intentioned" measures may be welfare reducing because of their impact on trade. Sanitary and phytosanitary (SPS) measures are typically applied to both domestically produced and imported goods.

Characteristics of SPS measures are as follows:

- SPS measures may address the characteristics of final products, as well as how goods are produced, processed, stored and transported.
- They may take the form of conformity assessment certificates, inspections, quarantine

requirements, import bans, and others.

- While some of these SPS measures may result in trade restrictions,
- Governments generally recognize that some restrictions are necessary and appropriate to protect human, animal and plant life and health.

There are three intergovernmental mechanisms of setting the standards by which the health of people, animals and plants are protected. These are:

Codex Alimentarius Commissions (CAC): which sets sanitary and technical standards for food safety including: food standards for commodities; codes of hygienic or technological practice; limits for pesticide residues in foods; and standards for contaminants and food additives.

Office International des Epizooties (OIE): which deals with animal health and zoonosis and sets sanitary standards for the international movement of animals and animal products.

International Plant Protection Convention (IPPC): which provides phytosanitary standards on how to prevent the spread and introduction of pests of plants and plant products.

Phytosanitary certificate: According to IPPC article V, this is a certificate in which the authorities of the country of origin declare that these products are healthy and free from plant diseases. It is needed for export and import of products.

1. Each contracting party shall make arrangements for phytosanitary certification, with the objective of ensuring that exported plants, plant products and other regulated articles and consignments thereof are in conformity with the certifying statement to be made pursuant to paragraph 2(b) of this Article.
2. Each contracting party shall make arrangements for the issuance of phytosanitary certificates in conformity with the following provisions:
   a) Inspection and other related activities shall be carried out only by or under the authority of the official national plant protection organization.
   b) Phytosanitary certificates, or their electronic equivalent where accepted by the importing contracting party concerned, shall be as worded in the models set out in the Annex to this Convention. These certificates should be completed and issued taking into account relevant international standards.
   c) Uncertified alterations or erasures shall invalidate the certificates.

Phytosanitary certification should be carried out by public officers who are technically qualified and duly authorized by the official national plant protection organization to act on its behalf and under its control with such knowledge and information available to those officers that the authorities of importing contracting parties may accept the phytosanitary certificates with confidence as dependable documents. Export phytosanitary inspection is conducted on the basis of each particular request from importing country and usually carried out at the Plant Protection Station of the seaport or airport of shipping.

Regulated articles for which phytosanitary certificate is needed- Commodities such as plants, bulbs and tubers, or seeds for propagation, fruits and vegetables, cut flowers and branches, grain,

and growing medium. It may also be used for certain plant products that have been processed where such products, by their nature or that of their processing, have a potential for introducing regulated pests (e.g. wood, cotton). A phytosanitary certificate may also be required for other regulated articles where phytosanitary measures are technically justified (e.g. empty containers, vehicles, and organisms). No Certificate is needed for plant products that have been processed in such a way that they have no potential for introducing regulated pests, or for other articles that do not require phytosanitary measures.

Export Inspection and Certification: The various steps involved in export inspection and certification of plants and plant products are as follows.

1. Registration of Application- The exporter or his agent shall submit an application in a format issued by NPPO, Faridabad (Appendix-5) in duplicate to officer-in-charge of concerned PQ station at the designated port through which he intends to export or to the concerned inspecting and certifying authority notified by the Ministry of Agriculture as reproduced in Appendix-1 (in document issued by NPPO, Faridabad) sufficiently in advance or at least 2-3 days prior to the actual date of shipment of consignment. However in the case of export of perishable commodities such as cut flowers, fresh fruits and vegetables, the above conditions may not apply. Also in the case of export of seed consignments such applications are filed 8-10 days prior to actual date of shipment. The application shall be accompanied by a copy of invoice, packing list, shipping/airway bill, letter of credit or trade agreement or purchase order, export license (if applicable) and fumigation certificate, if any. Besides these a copy of permit issued by the importing country in case of export of seeds/propagating plant material and wild life clearance certificate if the export is covered under the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) for the prohibited or restricted list of plants under CITES). On receipt of the application PQ officer shall scrutinize the application and if found complete in all respects shall register the application and assess the inspection fee. The applications made in respect of export/import-prohibited consignments are withheld or refused for issuance of PSC and also applications made in respect of preserved or pickled or frozen plant products. The exporter or his agent shall pay the inspection fee at the prescribed rates in Appendix-2 (letter No. 16-10/58-PPS dated 21st September 1960 issued by Ministry of Agriculture) On specific request from the exporter or his agent, the consignment may be inspected at places outside PQ station on payment of Rs. 10/- per visit towards outside inspection charges within municipal limits of town or corporation limits of city as the case may be. Further the exporter or his agent shall meet the travelling and dearness allowances of the PQ officer and staff deputed for inspection outside city or town as per their entitlement and also accommodation charges, if any. The above charges are paid in advance or immediately upon completion of the tour but before issuance of PSC. The inspection fee shall not be refunded in the case of cancelled or rejected application. The exporter shall abide by the terms and conditions stipulated by the inspecting and certifying authority. On receipt of inspection fees, a quarantine order is issued by the officer-in-charge of concerned PQ station for presenting the

consignment for inspection by the applicant.

2. Inspection / Sampling and Laboratory testing- The exporter or his agent shall present the consignment either at the office of PQ station or arrange for inspection at his premises or present the containers at any other approved place on scheduled date and time of inspection as per the quarantine order issued. The exporter or his agent shall provide necessary transport, labour and other facilities for opening, sampling, repacking, sealing etc.

Sampling of seed for propagation shall be in accordance with the International Seed Testing Association (ISTA) Rules, 1976. Sampling of cereals, pulses, oil seeds and others for consumption as per Bureau of Indian Standards (IS: 2814/1978 and IS: 3714/1978). The exporter or his agent shall associate with inspecting officer while undertaking inspection. The PQ officer deputed for inspection shall draw appropriate size of sample for detailed laboratory testing. The samples of grain, pulses, dry fruits, nuts, spices, fresh fruits & vegetables, cut flowers, coffee beans, groundnut, turmeric etc., that are meant for consumption are visually inspected with the help of illuminated magnifier specifically for live insect infestation. Pulses are usually subjected to X-Ray examination.

3. Fumigation and treatment of consignment- In the event of live insect infestation is noticed, the exporter or his agent shall arrange for fumigation of consignment or container at his premises or any other approved place by an approved pest control operator under the supervision of PQ officer. The exporter or his agent shall submit an undertaking for the purpose in Appendix-6 (in document issued by NPPO, Faridabad) along with payment of supervision charges of Rs.25/- per container. The exporter or his agent shall provide necessary transport/labour facilities, if the fumigation is carried out in the fumigation chambers at PQ station and pay fumigation or disinfestation or disinfection charges as prescribed above. The exporter or his agent shall pay storage charges @ Rs. 10/- per cu. m. space per day or part thereof, if the consignment is not immediately removed after degassing and re-inspection. The consignments shall be re-inspected after degassing of consignment or container to ensure freedom from live infestation.

4. Issuance/Rejection of Phytosanitary Certificate - Phytosanitary Certificates (PSCs) are issued in duplicate viz., original for the exporter and duplicate copy for office record, if consignment on inspection is found to be free from quarantine pests. However in case of re-exported consignments the PSCs are issued in re export format prescribed under IPPC. On specific request from the exporter or his agent PSC is re-issued after canceling the earlier original certificate to facilitate the incorporation of corrections/ amendments, subject to the production of shipping documents in proof thereof. Such re-issuance of PSC, for incorporating amendments / corrections, is done within 7-10 days from the date of issue of original certificate and thereafter no such requests shall be entertained. The issue of PSC will be rejected if the commodity on inspection is found to be a prohibited one or found affected by quarantine pest or the commodity could not be fumigated to render it pest-free as it is packed in impermeable container or packed with objectionable plant material or contaminated with soil or noxious weed seeds or processed food containing additives and preservatives and reasons for rejection shall immediately be

communicated in writing to the exporter or his agent under intimation to customs/port authorities.

Significance of Export inspection and Phytosanitary certificate- Export inspection and Phytosanitary certification is important for international trade because any change in international food safety standard would immediately affect the export firms as they have to face the consignment bans. It results in substantial costs in terms of lost sales, market share, and investments required re-entering export trade. There are many cases in which access of the products from developing countries to the international market was denied due to SPS measures such as Fish from Kenya, Raspberries from Guatemala, Shrimp from Bangladesh and Horticultural crops from Guatemala, Jamaica and Mali in 2003. European Community (EC) banned Indian marine products (seafood from Kerala India) in 1997. The Government of India responded to these developments by taking important steps to maintain the highest quality standards based on the health safety regulation requirements of the importing countries. The Seafood Exporters Association of India claims to have spent US$25 million on upgrading their facilities to meet the food safety regulations of the importing countries. Recently, Chicago agriculture specialists working in the O'Hare cargo located two 10 pound bags of rice among a shipment from India of household items and upon examination found a Khapra beetle cast skin and larvae. The Indian shipment was later destroyed. India will now have to fight the Khapra beetle to make sure its rice exports are not tarnished. USDA's Animal and Plant Health Inspection Service (APHIS) and India's National Plant Protection Organisation (NPPO) are now planning to jointly set up an agency to inspect rice exporting units and issue phytosanitary certificates.

Benefits of certification of export and SPS- Although new or more stringent standards can serve as a trade barrier, they act more often as a catalyst for progressive change. They are helpful to the exporting country in the following ways:

- Stricter standards can provide a stimulus for investments in supply-chain modernization.
- Provide increased incentives for the adoption of better safety and quality control practices.
- Help clarify necessary roles of government in food safety and agricultural health management.
- The compliance process can result in new forms of competitive advantage and contribute to more sustainable and profitable trade over the long term.

And also, there can be very positive returns in terms of continued and expanded access to high-value markets for those exporters that are able to comply.

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Eco-friendly Management of Diseases for Safe Storage and Export of Pulses

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Biotic and abiotic stresses cause economic losses in various crops including cereals, pulses, oil seeds and horticultural crops. On an average, crop losses due to diseases and insects are estimated to be around 15 to 20 per cent of the potential harvest. Even if half of the losses are avoided, India could harvest additional 15-20 million tonnes of food grains, a substantial quantity to wipe off the persisting malnutrition. Besides quantitative losses, the pesticides residues (due to non-judicious use) have become not-tariff barriers for our exports as is being experienced in several commodities. There was hue and cry against synthetic pesticides, when Rachel Carson published 'Silent Spring' in early 1960's. This led to awareness of adverse effects pesticides inflict upon environment and in fact, human health and development of resistance in target pest. The situation was aggravated by application of excessive and imbalance fertilizers, improper use of pesticides. So, it was necessiated to review high input crop production systems and practices and to devise a pest management strategy on a sustainable basis. A number of tactics have been employed in management of pests called IPM (Integrated Pest Management). The IPM could be simply defined as a holistic approach to pest control that seeks to optimize the use of a combination of methods to manage a whole spectrum of pests (pathogens, insects and weeds) within a particular cropping system. The present lecture elucidates such integration practices in the disease management of important pulses, meaning thereby discussing Integrated Disease Pest Management (IDPM), a 'sub-system' of IPM.

Pulses play an important role in Indian agriculture, majority of Indian population is vegetarian and derive their dietary protein form pulses. It would not be an overstatement if it is said that pulse crops have been the main stay of Indian agriculture, enabling the land to turn out reasonable quantities of food grains even after hardly receiving any manures or fertilizers. They figure prominently also in mixed cropping and various crop rotations under rain fed conditions and play vital role in sustainable agriculture in our country.

In India, presently the area under pulses is about 24.45 m ha and production 15.24 m t with a productivity of 623.0 kg/ha (Anonymous, 2005). If we look at the area, production and productivity of pulses as a whole over years it is evident that over the past decade, the area, production and productivity has almost stagnated. This resulted in sharp decline in the availability of pulses from 69 g/capita/day as against during 1951-56 to less than 35g/ capita/day during 2008. The need of pulses is 80 g/ capita/day as recommended by world health organization (WHO). Therefore, to meet this requirement of Indian population, we should increase our present production to 20 million tones. Pulses are not getting proper attention in production because of insufficient technology transfer for their production, susceptibility to number of biotic/ a biotic

factors and being less economical in comparison to cereals.

Chemical pesticides are available for management of diseases but resource starved farmers can not afford costly fungicides as pulses are generally grown by average farmers. They are resource poor with small fragmented holdings having little or no access to costly input credits and markets besides, the chemical pesticides may also cause environmental hazards. Due to increased magnitude of problems associated with the use of chemical pesticides. The need for developing non-chemical methods of disease management is being felt greatly.

Suppression of wilt has been observed in potted plants following soil inoculation with vesicular-arbuscular mycorrhizal (VAM) fungus. The endophyte colonized plant roots extensively which resulted in reduction in wilt incidence form 80% in non mycorrhizal to 26.6% in mycorrhizal plants. In such plants phosphate uptake efficiency was also significantly enhanced. Use of *Trichoderma viride, Gliocladium virens* and *Bacillus subtilis* has been found effective and eco-friendly for the control of wilt & root-rot complexes of chickpea and lentil crops.

Chemical seed treatment with Thiram (0.15%) + Carbendazim (0.1%) is proved to be the most effective against Fusarium oxysporium f. sp. ciceri. In *in vitro* evaluation of *Trichoderma* sp. against *F. oxysporium* f. sp. *ciceri* revealed the positive cumulative effect of *Trichoderma viride* + *Trichoderma harzianum* + *Trichoderma hamatum* in respect to the percent inhibition of the test fungus. Pot culture studies revealed that the soil application of *T. viride* (@ 25 kg/ha) as the most effective in reducing the incidence of chickpea wilt. Soil amendment with groundnut cake is proved to be effective against *F. oxysporium f. sp. ciceri* followed by neem cake. Genetic diversity already existing in pigeon pea germplasm lines can be exploited for breeding wilt resistant chickpea varieties. Thus, chickpea wilt incited by *F. oxysporium f. sp. ciceri* being soil borne disease could be managed by the integration of various practices like using resistant varieties, seed treatment with chemicals, seed and soil application of bio agents and amendment of soils with oilseeds cakes.

Biocontrol of wilt disease complex of pigeon pea, caused by *Meloidogyne incognita*, *Heterodera cajani* and *Fusarium udum*, was studied using 21 isolates of fluorescent Pseudomonads isolated from pathogen suppressive soils. The isolates Pf 718, Pf 719 and Pf 736 of *Pseudomonas fluorescens* and Pa 737 of *P. aeruginosa* caused 79, 84, 87 and 93% reductions in hatching of *M. incognita* and showed inhibition in the growth of *F. udum* in the dual inoculation. Isolate Pf 736 caused 309, 9 and 78% increases in seedling growth, phosphate solubilization and IAA production,respectively and also showed moderate HCN production. Isolate Pa 737 was the best to colonize roots of pigeon pea followed by Pf 736. The effects of these four isolates (Pf 718, Pf 719, Pf 736 and Pa 737) were studied on the wilt disease complex both in mono and multi-pathogenic combinations. The isolates Pf 736 caused greater increase in plant growth and higher reduction in nematode multiplication and wilting index followed by Pa 737, Pf 718 and Pf 719. The use of these isolates along with *Rhizobium* (pigeon pea strain) further increased plant growth and reduced nematode multiplication and wilting index. Twelve isolates production of siderophores in

Chrome azurol S (CAS) agar medium. The results suggest that P. fluorescens Pf 736 along with *Rhizobium* may be used for the management of wilt disease complex of pigeon pea.

Biological control of *Fusarium udum* causing wilt disease of pigeonpea was tudied in vitro, as well as, in vivo. *Aspergillus flavus, Aspergillus niger, Bacillus licheniformis* (strain-2042), *Gliocladium virens, Penicillium citrinum,* and *Trichoderma harzianum,* which were found to be the most potent ones in inhibition the radial colony growth of the test pathogen, were used as biological control by amending their inocula at different concentrations in pots and in pathogen-infested soil in the fields. Maximum reduction of the wilt diseases was observed with *G. virens* both in pots ad in the fields. The population of *F. udum* was found to be markedly reduced when the antagonists were applied in the soil. The study establishes that G. virens can be exploted for the biological control of wilt diseases at field level.

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Indian Agriculture and Global Agricultural Trade

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Agriculture has long been an epitome of Indian culture and prosperity. Agriculture is the source of livelihood of almost two thirds of the workforce in the country. The importance of agriculture to the country is best summed up by this statement: "If agriculture survives, India survives". Share of agriculture in GDP was 56.5% in 1950-51 which is continuously declining and is currently at 15.4%. Even during the British rule, which is considered as dark age for India, agriculture sector still prospered. Even at that time the agricultural products were exported to Britain though not much to the liking of native farmers. The 'globalization' of Indian economy in 1991 intends to amalgamate a country's economy with that of the world. Globalization and liberalization were intended to bring about expansion, prosperity and economic growth, with trade playing a significant role in the economic growth of any country. Even today India ranks 17th in global export and 11th in global import. The Indian exports witnessed robust growth during the five year period from 2004-05 to 2008-09. During this period, the exports grew at an average annual growth rate of 23.9 percent; increasing from US$ 83.5 billion in 2004-05 to US$ 185.3 billion in 2008-09. In 2008-09, the world witnessed one of the most severe global recessions in the post-war period that affected countries across the globe in varying degrees. Though India was not affected to the same extent as other economies of the world during this phase, yet its exports suffered a significant decline since October 2008 due to shrinkage of demand in the traditional markets of our exports and the reduced international prices of commodities. During 2009-10, after showing a negative growth for the first seven months, India's exports have entered the positive territory from November, 2009. The contribution of agriculture and allied activities to India's economic growth has declines from 19.5% in 1990-91 to 10.2% in 2005-06.

India's agri-exports can be divided into three broad categories, i.e. export of

a) Raw products,

b) Semi raw products

c) Processed and ready-to-eat products.

Raw products exported are essentially of low value high volume nature, while semi processed products are of intermediate value and limited volume and processed ready-to-eat products are of high value but low volume nature. The major agri-exports of India are cereals (mostly rice - Basmati and non-Basmati), spices, cashew, oilcake/meals, tobacco, tea, coffee and marine products.

India's agricultural sector has made huge strides in developing its potential through green revolution and introduction of technological innovations into agriculture. This progress is manifested in India's net trade position from food insufficiency to food sufficiency. Despite being an agrarian nation the impact of Indian agricultural export has been far from impressive. Though we

are able to increase the production of major crops by a large margin but still on the global scenario we lag far behind with agriculture contributing less than 3%.

India's agri-exports face certain constraints that arise from, low productivity per unit area, highly fragmented supply chain for fruits and vegetables, Non transparent pricing, Limited financial capability, Lack of quality and hygiene packaging, Lack of post-harvest infrastructure facilities like collection & grading centers, washing & packing facilities, reefer vans, pre-cooling & cold storages, intermediate cold storages, processing units & export house, high interest rates for Agri. Investment as well as Export finance, no market determined pricing conflicting domestic policies relating to production, storage, distribution, food security, pricing concerns and unwillingness to decide on basic minimum quantities for export makes Indian supply sources unreliable. Higher domestic prices in comparison to international prices of products of bulk exports like sugar, wheat, rice etc. make our exports commercially less competitive.

With so many competitors for different export commodities like that Vietman for rice, Malaysia for rubber, Mayanmar for fisheries etc India is facing a serious threat of increasing its agricultural export with increasing demand. India is a country with huge amount of natural resource and diverse climatic conditions. It still has many opportunities to grab in the field of global trade. Processed food products provide one such extended. Export market for flower industry, medicinal plants and others is also providing new avenues for increased trade along with contract and organic farming which are becoming more and more popular these days.

Keeping in mind the need of the hour various policy initiatives have been taken by government to bridge the gap between the actual and potential agricultural export. Some of these include setting up of special economic zones, Agricultural export zones and Vision 2015 for increase in value added processing. New trade policy was also formulated in 2004-09 with special focus on agriculture to increase growth in export sector at an average annual growth rate of 23.9%; and an export hub for supply of agricultural products.

The recent growth in Indian exports is primarily led by an increase in factor productivity, growth in world trade, increase in intra-industry trade and external sector reforms. While these factors certainly play an important role in explaining the surge in exports, the removal of supply bottlenecks is necessary to sustain this high export growth. Supply-side factors are extremely important and need to be addressed in this regard. On the domestic front, there is a necessity to put a proper infrastructure in place and eliminate the problems associated with burdensome government regulations and procedural bottlenecks. Market intelligence and creating awareness in international market about quality of products need to be strengthened to boost agricultural exports and issues relating to total output growth, efficiency, equity and sustainability.

Pest Risk Assessment for Quarantine Pests

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Organism of quarantine significance may include any pest or pathogen that a government conceder to pose a threat to country's agriculture and environment. Such organisms are usually exotic to that country or region but may also include exotic strain or race of domestic organism. An exotic species of pest or pathogen must first gain entry and become establish to pose any threat to local plants. It is an extremely difficult proposition to predict accurately whether and exotic organism will become establish and become economically important. In a relatively few cases, the patho-geographical approach has lead to prediction of the occurrence of the pathogen based on the knowledge of the life cycles, distribution of the pathogens and ecological characteristics of the host and pathogen.

Analysis of pest and pathogen risk is the decisions making process that brings the biological approach in to play. The analysis is based on two general precepts *the benefit must exceed the risk* and *the benefit must exceed the cost.* The benefit include the opportunity the new crops or the new varieties of established crops or to introduce new genes to improve existing varieties. When costs are entered into pest risk analysis, the costs of adequate safeguards are taken into account. International standards for phytosanitary measures provide details for the conduct of pest risk analysis (PRA) to determine if pests are quarantine pests. It describes the integrated processes to be used for risk assessment as well as the selection of risk management options.

Pest Risk Assessment can be divided into 3 steps:

Step 1 – Pest categorisation

Step 2 – Probability of entry, establishment and spread of the pest

Step 3 – Assessment of potential economic consequences

Pest Categorization

At the outset, it may not be clear which pest(s) identified in Stage 1 require a PRA. The categorization process examines for each pest whether the criteria in the definition for a quarantine pest are satisfied. In the evaluation of a pathway associated with a commodity, a number of individual PRAs may be necessary for the various pests potentially associated with the pathway. The opportunity to eliminate an organism or organisms from consideration before in-depth examination is undertaken is a valuable characteristic of the categorization process. An advantage of pest categorization is that it can be done with relatively little information; however information should be sufficient to adequately carry out the categorization.

Elements of categorization

The categorization of a pest as a quarantine pest includes the following primary elements:

A. Identity of the pest

B. Presence or absence in the PRA area

C. Regulatory status

D. Potential for establishment and spread in PRA area

E. Potential for economic consequences (including environmental consequences) in the PRA area

Conclusion of pest categorization

If it has been determined that the pest has the potential to be a quarantine pest, the PRA process should continue. If a pest does not fulfill all of the criteria for a quarantine pest, the PRA process for that pest may stop. In the absence of sufficient information, the uncertainties should be identified and the PRA process should continue.

Assessment of The Probability of Introduction and Spread

Pest introduction is comprised of both entry and establishment. Assessing the probability of introduction requires an analysis of each of the pathways with which a pest may be associated from its origin to its establishment in the PRA area. In a PRA initiated by a specific pathway (usually an imported commodity), the probability of pest entry is evaluated for the pathway in question. The probabilities for pest entry associated with other pathways need to be investigated as well. For risk analyses that have been initiated for a specific pest, with no particular commodity or pathway under consideration, the potential of all probable pathways should be considered. The assessment of probability of spread is based primarily on biological considerations similar to those for entry and establishment.

Probability of entry of a pest

The probability of entry of a pest depends on the pathways from the exporting country to the destination, and the frequency and quantity of pests associated with them. The higher number of pathways, the greater the probability of the pest entering the PRA area. Documented pathways for the pest to enter new areas should be noted. Potential pathways, which may not currently exist, should be assessed. Pest interception data may provide evidence of the ability of a pest to be associated with a pathway and to survive in transport or storage.

Probability of establishment

In order to estimate the probability of establishment of a pest, reliable biological information (life cycle, host range, epidemiology, survival etc.) should be obtained from the areas where the pest currently occurs. The situation in the PRA area can then be compared with that in the areas

where it currently occurs (taking account also of protected environments such as glass- or greenhouses) and expert judgment used to assess the probability of establishment. Case histories concerning comparable pests can be considered. Examples of the factors to consider are:

- Availability, quantity and distribution of hosts in the PRA area
- Environmental suitability in the PRA area
- Potential for adaptation of the pest
- Reproductive strategy of the pest

Probability of spread after establishment

A pest with a high potential for spread may also have a high potential for establishment, and possibilities for its successful containment and/or eradication are more limited. In order to estimate the probability of spread of the pest, reliable biological information should be obtained from areas where the pest currently occurs. The situation in the PRA area can then be carefully compared with that in the areas where the pest currently occurs and expert judgment used to assess the probability of spread. Case histories concerning comparable pests can usefully be considered. Examples of the factors to consider are:

- Suitability of the natural and/or managed environment for natural spread of the pest
- Presence of natural barriers
- The potential for movement with commodities or conveyances
- Intended use of the commodity
- Potential vectors of the pest in the PRA area
- Potential natural enemies of the pest in the PRA area.

The information on probability of spread is used to estimate how rapidly a pest's potential economic importance may be expressed within the PRA area. This also has significance if the pest is liable to enter and establish in an area of low potential economic importance and then spread to an area of high potential economic importance. In addition it may be important in the risk management stage when considering the feasibility of containment or eradication of an introduced pest.

Conclusion on the probability of introduction and spread

The overall probability of introduction should be expressed in terms most suitable for the data, the methods used for analysis, and the intended audience. This may be quantitative or qualitative, since either output is in any case the result of a combination of both quantitative and qualitative information. The probability of introduction may be expressed as a comparison with that obtained from PRAs on other pests.

Conclusion regarding endangered areas: The part of the PRA area where ecological factors

favour the establishment of the pest should be identified in order to define the endangered area. This may be the whole of the PRA area or a part of the area.

Assessment of Potential Economic Consequences

Requirements described in this step indicate what information relative to the pest and its potential host plants should be assembled, and suggest levels of economic analysis that may be carried out using that information in order to assess all the effects of the pest, i.e. the potential economic consequences. Wherever appropriate, quantitative data that will provide monetary values should be obtained. Qualitative data may also be used. Consultation with an economist may be useful. In many instances, detailed analysis of the estimated economic consequences is not necessary if there is sufficient evidence or it is widely agreed that the introduction of a pest will have unacceptable economic consequences (including environmental consequences). In such cases, risk assessment will primarily focus on the probability of introduction and spread. It will, however, be necessary to examine economic factors in greater detail when the level of economic consequences is in question, or when the level of economic consequences is needed to evaluate the strength of measures used for risk management or in assessing the cost-benefit of exclusion or control.

Pest effects

In order to estimate the potential economic importance of the pest, information should be obtained from areas where the pest occurs naturally or has been introduced. This information should be compared with the situation in the PRA area. Case histories concerning comparable pests can usefully be considered. The effects considered may be direct or indirect.

Conclusion of the assessment of economic consequences

Wherever appropriate, the output of the assessment of economic consequences described in this step should be in terms of a monetary value. The economic consequences can also be expressed qualitatively or using quantitative measures without monetary terms. Sources of information, assumptions and methods of analysis should be clearly specified.

Endangered area: The part of the PRA area where presence of the pest will result in economically important loss should be identified as appropriate. This is needed to define the endangered area.

Degree of Uncertainty

Estimation of the probability of introduction of a pest and of its economic consequences involves many uncertainties. In particular, this estimation is an extrapolation from the situation where the pest occurs to the hypothetical situation in the PRA area. It is important to document the areas of uncertainty and the degree of uncertainty in the assessment, and to indicate where expert judgment has been used. This is necessary for transparency and may also be useful for identifying and prioritizing research needs.

Table: 1 Examples of plant pathogens introduced into some countries.

Disease and pathogen	Introduced from	Introduced into	Year of introduction
American goose berry mildew (*Sphaerotheca morsuvae*)	N. America	England	1899
Bacterial canker of tomato (*C.michiganense pv. michiganense*)	U.S.	U.K.	1942
Bacterial leaf blight of paddy (*X.campestris* pv. *oryzae*)	Philippines	India	1959
Black rot of crucifers (*X. campestris* pv. *compestris*)	Java	India	1929
Black shank of tobacco (*Phytophthora nicotianae*)	Holland	India	1938
Blister rust of pines (*Cronartium ribicola*)	Europe	U.S.	1910
Bunchy top of banana (Viral)	Sri Lanka	India	1940
Chestnut blight (*Endothia parasitica*)	Asia	U.S.	1904
Citrus canker (*X.campestris* pv. *citri*)	Asia	U.S.	1907
Powdery mildew of cucurbits (*Erysiphe cichoracearum*)	Sri Lanka	India	1910
Downy mildew of grapes	U.S.	France	1878
(*Plasmopara viticola*)	Europe	India	1910
Downy mildew of maize (*Sclorospora phillipinensis*)	Java	India	1912
Dutch elm (*C. ulmi*)	Holland	U.S.	1928-30
Flag smut of wheat (*Urocystis tritici*)	Australia	India	1906
Fire blight of apple (*E. amylovora*)	N. America	New Zealand	1919
Golden nematode of potato	Europe	U.S., Mexico	1881
(*G. rostochiensis*)		India	1961
Hairy root of apple (Viral)	England	India	1940
Late blight of potato	S. America	Europe	1830
(*Phytophthora infestans*)	U.K.	India	1883
Leaf rust of coffee	Sri Lanka	India	1879
(*Hemileia vastatrix*)	Asia, Africa	Brazil	1970
Onion Smut (*Urocystis cepulae*)	Europe	India	1958
Paddy blast (*Pyricularia oryzae*)	S. E. Asia	India	1918
Peanut rust	Brunei	Brazil	-
(*Puccinia arachidis*)	U.S.		
Powdery mildew of grape (*Uncinula necator*)	North America	England	1845
Powdery mildew of rubber (*Oidium heavea*)	Malaya	India	1938
Rye grass seed infection (*Gleotinia temulenta*)	New Zealand	Oregon	1940
Wart of potato (*Synchytrium endobioticum*)	Netherlands	India	1953
Wheat bunt (*Tilletia caries*)	Australia	California, U.S.	1854
Witches broom of cocoa (*Marasmitus perni*)	Trinidad	South America	1974-75

Onion and Garlic Export – Problems and Prospects

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Onion and garlic both are important commercial horticultural crops grown in India. India is the 2nd largest producer of onion in the world, the first being China. Maharashtra, Gujarat, UP, Karnataka, Rajasthan and Orissa are the major onion producing states accounting for more than 70% of the production. In garlic also India ranks second in production, the first being China. MP, Gujarat, Orissa, Maharashtra, Rajsthan and UP are the leading states covering more than 87% of the production. M.P. is however, leading state accounting to 28.41% of the production. Onion is an indispensable item in every kitchen as condiment and vegetable, hence commands an extensive internal market. The onion is also an export oriented crop earning valuable foreign exchange for the country. More than 70% foreign exchange earning, amongst fresh vegetables, comes from onion. Garlic is also a condiment crop and there is constant demand in the domestic market. It also has export demand.

Onion and garlic both are traditional exportable crops. Even in 1951-52 onion export was 5000 tonnes per annum and that of garlic in 1961-62 was over 2000 tonnes.In 60 (s) the export was almost doubled and further in 80(s) it jumped manifold touching 2.74 lakh tonnes. It touched new height during 2002-03. The export during 2010-11 was 11.63 lakh tonnes with value of Rs.174 crores. Presently onion is being exported to Malaysia, Dubai, Qatar, Kuwait, Singapore, Sri Lanka, Mauritius, Bangladesh and Nepal. The Netherlands is leading exporter of onion contributing to about 17.60% of world export. India and USA are at 2nd and 3rd position contributing to about 15.20% and 8.00% share respectively in world export. Onion export though earlier was canalised through National Agricultural Cooperative Marketing Federation of India (Nafed), now it is canalised through followings 12 state canalising agencies.

1. Spice Trading Corp.Ltd, Bangalore
2. Gujarat Agro Industries Corp.Ltd.,Ahemdabad
3. Maharashtra State Agril.Marketing Board, Pune
4. National Cooperative Consumer's Federation of India Ltd., New Delhi
5. Karnataka State Cooperative Marketing Federation Ltd., Bangalore
6. A.P. State Trading Corporation, Hyderabad
7. North Karnataka Onion Growers Co-operative Society Ltd., Hubli
8. West Bengal Essential Commodities Supply Corporation(WBECSC) Ltd., Kolkata
9. MP State Agro Industries Development Corporation (MPSAIDC) Ltd., Bhopal
10. Karnataka State Produce Processing and Export Corporation (KAPPEC) Ltd., Bangalore
11. MP Oilfed, Bhopal

12.AP Markfed, Hyderabad

Nafed is the nodal agency which monitors the export through other canalising agencies. Nafed exports onion on its own and also through Associate Shippers. The export is mainly from Maharashtra and Tamilnadu ports. Export to Bangladesh and Nepal is from UP and Bihar by Road. Some times export to these countries is also done from Maharashtra.

Garlic is exported to Quatar, Saudi Arabia, UAE, Bahrain, Mauritius, Kuwait, Bangladesh and Sri Lanka. The export has been ranging from 0.10-3.0% of domestic production. Export of garlic is under O.G.L. Exporters of garlic purchase their requirement from important assembly markets in Gujarat, MP, Tamilnadu, Karnataka and UP. The The export of garlic however, came down due to not having required quality and less availability .

Varieties and types

Presently the export is of mainly common big onion (90%). Agrifound Dark Red, N-53, local Bellary Red, Patna Red, Agrifound Light Red and local Poona Red are in this group. About 10% is of small onions such as Agrifound Rose, Bangalore Rose and multiplier onions like CO4, CO3 and Agrifound Red. The big onions are being exported to Gulf countries, Sri Lanka, Bangladesh, Singapore and Malaysia. Small onions are exported to Bangladesh. Medium sized are exported to Singapore and Malaysia. Yellow onion, though are in demand in European and Japanese markets, are not being grown on commercial scale. The custom farming of yellow onions can be organised. It is, however, necessary to ship in refrigerated or electrically ventilated containers in view of short day yellow onions having poor keeping quality.

In case of garlic, main production is of small cloved garlic bulbs having more than 20 cloves. Some production of bigger cloved garlic is being taken up near Kodaikanal and Mettupalayam in Tamilnadu and Northern hills of UP, HP and J&K. The export of only selected bulbs of more than 40 mm size is mainly from MP. Recently NHRDF has developed two bigger cloved garlic varieties i.e. Yamuna Safed-3 (G-282) for plains and Agrifound Parvati (G-313) for Northern hills. The varieties in small clove types developed recently are Agrifound White, Yamuna Safed and Yamuna Safed-2. Presently export of garlic is of small cloved varieties.

Quality requirement of various foreign markets

Onion

There is not much difference in the requirement of onion of different existing importing countries. The requirement in general is for dark red to light red coloured varieties depending upon the availability in the market at a particular time.

Size

Gulf countries require 40-60 mm onions so also Mauritius. Far East Countries and Nepal requires medium sized onions i.e 35-40 mm sized bulbs. Bangladesh require medium size onions of 30-35 mm size. Sri Lanka required 40-50 mm sized bulbs.

Shape

Major requirement is of round shaped onions of all the markets.

Pungency

The requirement of all existing markets is mainly for strong pungent.

Garlic

In case of garlic though earlier demand from Bangladesh and Sri Lanka as also Middle East countries was of smaller cloved garlic types grown in India, now only bigger cloved garlic bulbs are in demand from all over the world. Preference is for garlic bulbs having 40-60 mm with 10-15 cloves in each bulb. Philippines still require smaller cloved varieties. Govt. of India has prescribed certain grade designation for different qualities of garlic for export. The details of grade designation and definition of different qualities of garlic are mentioned as under:

Tolerance for requirement in respect of general characteristics

For incidental error in sizing not more than 5% by weight may be of the next lower grade.To allow for variations other than size, incidental error to proper grading and handling not more than 10% by weight of garlic in any containers may be below the requirement specified under general characteristics but not more than a total of 1/5th of this tolerance or 2% shall be allowed for garlic which is affected by decay.

Constraints in onion export

1. Non availability of export worthy stocks
2. More internal demand and high ruling prices
3. Unawareness about proper post harvest practices and quality
4. Packing materials
5. Inadequate transport facilities
6. Non availability of adequate storage and handling facilities at the ports and also suitable vessels
7. Inadequate market intelligence

Strategies to overcome the problems

1. Production and distribution of quality seeds of improved varieties in adequate quantities
2. Development of disease and insect pests resistant and heat / moisture stress tolerant varieties
3. Development of biological control measures against pests and diseases
4. Development of yellow colour hybrids and OPs for export to European and Japanese markets
5. Development of bigger bulblet varieties in multiplier types
6. Development of bigger cloved garlic
7. Training of trainers, farmers, traders and exporters
8. Creation of adequate curing and storage facilities by farmers, traders and exporters
9. Improvement in packing
10. Creation of proper and adequate facilities for handling the perishable at ports

Post Harvest Management of Vegetables for Export

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India, with diverse soil and climate types comprising several agro-ecological regions, provides ample opportunity to grow a variety of crops. The aggregate cropping patterns of the country are represented by the gross cropped area allocation among different crops and commodity groups. Horticultural crops form a significant part of total agricultural produce in the country comprising of fruits, vegetables, root and tuber crops, flowers, ornamental plants, medicinal and aromatic plants, spices, condiments, plantation crops and mushrooms and have become key drivers of economic development in many of the states in the country. They contribute 29.5 per cent to Agriculture GDP. This calls for technology-led development. Horticultural crops play a unique role in India's economy by improving the income of the rural people. Cultivation of these crops is labour intensive and as such generates lot of employment opportunities for the rural population.

Fruits and vegetables are fastest growing sectors within horticulture. India produces around 111.77 million metric tonnes of vegetables and 57.73 million metric tonnes of fruits, which respectively accounts for nearly 11.9% and 10.9% of country's share in the world production of vegetables and fruits. India ranks second in world in both categories. From the year 2000 onwards production has been constantly increasing. Fruits and vegetables combined form the major contributor to the total horticulture production. Fruits show a constant linear increase in production. A constant trend is observed in production of plantation crops, spices and flowers also. Of all fruit produced in the country, banana accounts for the maximum quantity (about 33%). Five fruits – mango, banana, citrus, guava and apple– alone cover about 75% of the total fruit produced in the country. Likewise in vegetables potato occupies the highest place followed by brinjal. In spite of potato being number one amongst vegetables produced in the country, India ranks third in the world for this product.

In spite of spectacular growth in the production of horticultural crops about 25-30% produces lossed due to post harvest spoilage. So there is need to have a strong post harvest infrastructure for post harvest management of these perishables. Post harvest technology (PHT) is inter-disciplinary "Science and Technique" applied to agricultural produce after harvest for its protection, conservation, processing, packaging, distribution, marketing, and utilization to meet the food and nutritional requirements of the people in relation to their needs. Use of appropriate PHT reduces the post harvest and storage losses; adds value to the product, generates employment in the village and re-establishes agro-industries in rural sector.

Post harvest Diseases and Its management

Some of the common post harvest diseases of fruits and vegetables are Blue and Grey mould of Pome fruits and Grapes, Bacterial soft rot of Cucurbits, Sclerotium rot in legumes and

many more.

Management of post harvest diseases has two strategies include traditional and emerging technologies. Traditional strategies include fungicides, hygiene practices, maintenance of host resistance, preharvest factors, prevention of injury, ionising radiation ,heat treatments. Emerging technologies include biological control, constitutive and induced host resistance and natural fungicides. Management practices comprises of cultural practices, physical practices, chemical treatment and maintenance of host resistance.

1. Cultural practices include- use of suitable production technology (tillage, irrigation, pruning, harvesting), Strict hygiene(floor management), balanced nutrition (INM), maintaining proper physiological-pathological state, Reduction of primary inoculum (carry over) and Avoid cuts/wounds/bruises (infection courts) .

2. Physical methods include- pre-cooling which slows down enzymatic activities, cleaning with chlorinated water (for removal of dust, soil, debris, insects, spray residue), curing enhances development of periderm and waxing helps in reducing transpiration/respiration rate.

3. Chemical methods comprises of pre and post harvest treatments. Post harvest treatment includes dipping in chemicals such as Benzimidazole, Calcium chloride and Aromatics (Dichloronitro aniline and Sodium orthophenyle phenate). Wax coating and sugar impregmentation, fumigation with Ozone/SO_2 which induces resistant, Impregnated wrappers of Sodium bisulphate, Sodium orthophenyl butarate , Sodium metabisulphate , Potassium iodide, Dichloronitro aniline, Diphenyl amine , Sodium-O-Phenyl phenate, Filtrate of S*treptomyces thermoflavu.* Skin coating with Wax impregnated with carbendazim/thiabendazole , colloidal solution of Carboxy Methyle Cellulose, sucrose, oils: mustard, caster, neem, paraffin / esters of fatty acids and polysaccharides. Several bactericides are also used in post harvest management for this chlorinated water used as general disinfectant (eradicates bacteria suspended in water, eradicates bacteria on surface of produce, and prevents infection in surface openings), antibiotics (streptomycin and tetracycline) found effective against soft rot in potato, tomato, capsicum & leafy vegetables.

4. Host resistance is another major practice but less utilized in India. There are many varieties which have good keeping quality but not commonly available in all the crops. There is need to bred such verities wherever required.

Post harvest Cooling

Post harvest cooling rapidly removes field heat from freshly harvested commodities before shipment, storage, or processing and is essential for many perishable crops. It Suppress enzymatic degradation and respiratory activity (softening), Slow or inhibit water loss (wilting) , slow or inhibit the growth of decay-producing microorganisms (molds and bacteria) ,reduce production of ethylene (a ripening agent) or minimize the product's reaction to ethylene. The choice of cooling method depends on the economic constraints, product packaging requirements, product flow capacity, the nature of the product. Common cooling methods includes forced-air cooling room

cooling, vacuum cooling, evaporative cooling, top or liquid icing and hydrocooling .

Packaging

For maintaining the quality and safe handling of fruits and vegetables proper packaging is required. Packaging is required for containment ,protection and identification .Various types of packaging materials are used viz. wood which includes pallets, literally form the base on which most fresh produce is delivered to the consumer ; pallet Bins, substantial wooden pallet bins of milled lumber or plywood are primarily used to move produce from the field or orchard to the packing house ;Wooden Baskets and Hampers , wire-reinforced wood veneer baskets and hampers of different sizes were once used for a wide variety of crops from strawberries to sweet potatoes. They are durable and may be nested for efficient transport when empty. Corrugated fibreboard, manufactured in different styles and weights. Because of its relativity low cost and versatility, it is the dominant container material. Double-faced corrugated fiber board is the predominant form used for produce containers. It is produced by sandwiching a layer of corrugated paperboard between an inner and outer liner (facing) of paper-board. Other packaging materials includes pulp container, paper and mesh bags, plastic bag, shrink wrap, rigid plastic packages etc.

In order to overcome the post harvest losses there is need to develop an integrated package for management of Post Harvest diseases of perishable crops employing suitable technologies to support the growers for supplying hygienic and quality produce to the consumers. Our approach should be to generate database for post harvest yield loss , develop hygienic cultural practices, effective and safe chemicals for pre and post harvest treatments, identifying/developing suitable bioagents and finding optimum combination of physical/biological factors and controlled environment for increasing shelf life of perishable commodities

Post harvest Handling and Storage of Onion

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India is the second largest producer of onion in the world accounting for 16 percent area and 10 percent of production. In our country, onion is grown in 0.19 million hectare with production of 4.0 million tones. The major onion growing states are Maharashtra, Gujarat, Karnataka, Bihar and A.P. Maharashtra alone produces around 16 percent of the total production of India. Onion is important constituent of our daily diet and its demand remains same round the year. Thus a considerable quantity of onion is stored to fulfill the domestic and export demand during the lean season i.e. July to September. It is estimate that around 2.0 million tones of onion were stored annually to fulfill the demand from June to October.

Onion is stored in ambient storage condition in our country where the storage losses are very high. It is estimated that 40- 50% of the stored onion never reaches to the consumers because of various types of losses. These losses are comprises of physiological loss in weight (PLW) i.e. moisture losses and shrinkage (30-40 %), rotting (10-12 %) and sprouting (8-10 %).The higher storage losses were due to physiological loss of weight occurring during the months of May to July when mean temperatures are high. The rotting losses are high in the high humid months of rainy season. The sprouting of onion starts in September -October when the temperatures starts decreasing.

Factors effecting storage life of onion

The storability of onion is influenced by various genetical, pre and post harvest factors. The genetically controlled factors, which may influence the storage performance, include dry matter content and pungency and skin colour, skin number and quality and length of natural dormancy period of the variety. The pre harvest factors, which contribute to storage quality, include the fertilizers and water regime during cultivation, treatment of sprouts suppressants and fungicides. The time and method of harvesting curing and storage environment, packing materials also have considerable impact on storage life of the onion.

1. Varietal characteristics

The inherited qualities, which leads to give good storage life of onion, are high dry matter content, high pungency and long dormancy. The genetic linkage between these qualities particularly between dormancy and high dry matter content is not fully stabilized. The varieties having several layers of dry skin have better chances of performing well during storage. The locally adopted short day onion varieties tend to have better storage quality than the imported short day cultivars. The poor keeping varieties have low T.S.S., low dry matter content, high relative loss of water in the period immediately after harvest and poor skin retention with only one

number of skin.

2. Cultural Practices

The cultural practices during crop growth and development effects the storage life of onion. Among them fertilizers, irrigation, time of harvest etc. plays significant role in storage life of onions. Time of harvest is important for yield maximization and quality production. The yield is maximum if the bulbs are left in the field until all the leaves have completed dried. But under relativity wet soil conditions complete drying of leaves seldom occurs. Further the delayed harvest may result in reduction in skin quality, sprouting rooting and reduction in firmness. Thus it is generally recommended that onion should be harvested when 50% plants show neck fall.

3. Pre-harvest treatments

The foliar application of fungicides 10 to 15 days before harvesting helps in reduction of pathogens load and helps in reduction of diseases in storage. Therefore the mature crop should be sprayed with fungicide such as Bavistin (0.2%) 15 days prior to harvesting. The use of sprout suppressants such as maleic hydrazide (1500-2500 ppm) 2 to 4 week before harvesting have been found successful in control of sprouting in storage.

4. Field curing, removal of tops and shade curing

The proper drying of leaves (field curing) allows the inhibitors presence in the leaves to tickle down in the bulbs. These inhibiters plays significant role in the dormancy of bulbs. Further the complete drying of leaves closes the neck of bulbs which reduce the chances of infection of the bulbs. The onion should be dried with intact leaves for 3-4 days after harvesting. while cutting the leaves, 2-3 cm long neck should be kept along with the bulbs. These bulbs should be kept under ventilated shade for 2 to 3 weeks for proper drying of bulbs.

5. Grading

The onion is graded in three grades i.e. A, B, C grades according to their size if the bulbs. Only A and B bulbs should be kept in store. In India grading of onion is usually performed manually either before storage or before marketing. The grading with machine reduces cost on labour charges and increases precision.

6. Post harvest treatments

There are several post treatments are recommended for reducing storage losses in onion. The fumigation of bulbs with sulphur before storage decreases the infection of moulds. The treatment of well cured onions with 60 Gy to 90 Gy gamma irradiation with in one month of harvesting completely eliminated the problem of sprouting of onion during storage..

7. Packing

Dry onions are sorted, cleaned, sized and graded just prior to packaging. The onion is generally packed in Hessian cloth bags of various sizes for marketing. Now the use of Lino bags

and consumers pack (1 to 5 kg) is also going popularly.

8. Storage method and storage environment

The temperature and relative humidity are the prime important factors associated with storage of onion. A high relative humidity (more than 75%) is the biggest enemy of onion storage as it promotes root growth and development of storage diseases. In contrast the humidity (less than 65%) leads to excessive moisture loss from the bulbs, resulting shriveling and loss of weight. The dormancy of bulbs, which inhibits sprouting, is primary temperature dependent. Sprouting is high between 5^0C to 20^0 C. As far as the weight losses is concerned it is less at 0-2^0C or moderately lower at 25-30^0C. The temperature of 5 to 25^0 and more than 30^0 increases the weight loss. Thus there are two distant temperature conditions and one defined humidity range suitable for safe storage of onions. Thus the onion storage structure should be planned and designed storage in such a manner that it can achieve and maintain the desired storage conditions in lowest possible cost with in the available resources.

Points to be consider for construction of storage structures

1. It should be constructed in such a manner so that it can maintain the required temperature and relative humidity.
2. The width of one stake should not be more than 4 fit. The maximum height and length should not be more than 5 fits and 15 fits, respectively.
3. Bottom ventilated of 1 to 1 ½ fit should be provided for proper aeration.
4. The floor and sidewall should be constructed with wooden bantam or bamboos.
5. The roof should be constructed with asbestos sheet or Mangalore tiles or thatched galvanized iron sheet are not suitable for roofing material for storage structures.
6. The structures should be construction at an elevated place. There should not be any water body around the storage. The single row should be constructed in North-South direction while double row structure should be constructed in East-West direction.

9 .Cold storage

The onion can be stored under cold storage at 0-2^0C and 65-70% humidity with very minute losses. But cost of storage and the problem of sprouting in post cold storage in onion is main problem. This problem of sprouting can be minimized by gamma irradiation treatment. The cold storage of onion is successful if combined with r-irradiation techniques. In India cold storage of onion is till in experiment stage.

10. Storage diseases and disorders

1. **Neck Rot.:** Neck rot is the most common storage disease. The symptom appears as Water-decay at neck area, which moves down word through entire bulb. Light gray fungal growth is generally visible at neck infection and on outer scales. Seed treatment before planting, Proper drying and curing of onion are essential to prevent this storage disease.
2. **Black mould:** Black discoloration and shriveling at neck and on outer cales caused by the fungus *Aspergillus nigre*. This *is* often associated with brushing and leads to bacterial soft

rot. Low temperature storage delays growth of fungus, but it is high under high temperature and high humid conditions. Proper shading curing reduces infection.

3. **Bacterial rots:** Several types of bacterial diseases have ben reported to affect the onions in storage. Among them slippery skin, sour skin are common. Water-soaked, foul smelling, viscous liquidly rot is caused by *Erwinia.* The slippery skin is generally visible only at neck area and upon cutting to expose inner scales. Scales have a watery-cooked appearance. In Sour skin, slimy, yellow-brown decay generally limited to inner scales, which give off a sour odor when exposed. These diseases can be control by proper sanitation and crop rotation.
4. **Greening:** This disorder is associated with high nitrogen application, direct exposure of sunlight. It can be reduced by use of less nitrogen and use of proper shading/roofing methods.
5. **Sprouting:** sprouting is a genetic characteristic of bulb which is temperature dependent. It can be reduced by sprout suppressant and irradiation

Post harvest handling and storage of Garlic

Garlic is an important spice crop. Around 1.4 million tones of garlic is produced in India from 0.18 m ha area. Contrary to onion, it is grown only in winter (rabi) season and usually harvested in March-April. it is stored for 6-9 months to fulfill demand round the year.. The major losses in garlic are weight loss (10-15%) infection of diseases (15-20%).

Factors effecting the storage losses in garlic

Similar to onion, garlic storage is also affected by several factors. Although vary little work have been carried out on garlic storage. The garlic varieties differs considerable in the inherent duration of dormancy. Generally sprouting is not a problem in garlic. The sprouting/ internal sprouting occurs only after October-November. The higher nitrogen application and use of more irrigation particularly in the later part of growth and development is detrimental for garlic storage. The time of harvesting and curing are the other factors influencing the storage of garlic. The late harvesting of garlic is to be avoided as it leads to re-sprouting of cloves.

The leaves of garlic are removed only after complete drying of leaves. It has been reported that the garlic with intact leaves has more storage life than the topped garlic.

The optimum conditions for garlic are 25 to 30^0C temperature and 65-70% relative humidity. The small quantity of untopped garlic is stored by hanging the bundle but large quantity of garlic may be stored in circular heaps of 1 m diameter and 1to 1.5-meter height. The topped garlic can be packed in Hessian cloth bags and can be stored for 3-4 months. The well-ventilated stores were found better than traditional store for storage of garlic..

Measures of reduction of losses in garlic

1. Selection of good varieties.
2. Judicious use of nitrogenous fertilizers and irrigation water
3. Timely harvesting and proper curing bulbs.

4. Proper drying of leaves and shade curing.
5. Fumigation and use of ventilated store reduces the storage losses.
6. The keeping garlic with intact leaves in crops found better than keeping in bags.

Post harvest diseases and Pest

1. **Blue mould:** Penecillium Corymbiferum causes this disease. The affected clove became soft shrivels and covered with blue-green powdery spores. The infection is carried from field and heavy bulbs may also carry fungus on the out scales. Proper drying and field sanitation reduces in the infection of diseases.
2. **Black mould:** This is called by *Aspergillus.,* which causes deposition of black mould on outer layer of bulbs and cloves. The infection can be reduced by proper shade curing of bulbs.
3. **Mites:** Sometimes mites found damaging the cloves in the store. The fumigation of bulbs will methyl bromide (35 g/cubic m area) after harvest and before storage can control the mites.

Rapid and Accurate Identification of Microorganisms to Species Level Using Microbial Identification System: Biolog

R. P. Singh, Laxmi Rawat and J. Kumar

Biolog Microbial Identification System is based on metabolic phenotypes. It is based on the theory that a species of bacteria develops a unique metabolic finger-print on a set of carbon sources and biochemicals. The cultured bacteria are tested for utilization of different carbon sources and biochemicals, which are pre-filled and dried into a 96 well test plate. Cells utilizing nutrient, respire and release energy which reduces proprietary Tetrazolium dye to form a distinct purple colour. Biolog data collection software is used to record the unique metabolic profile into the computer which can be compared with thousands of profiles (corresponding to thousands of species) stored in the Biolog databases. If the profile is matched, computer displays the identified species.

Biolog has designed proprietary microplates for identification of a wide range of microbes upto species level, such as Gen III plate (for gram negative and gram positive aerobic bacteria), AN plate (for anaerobic bacteria), YT plate (for yeast) and FF plate (for filamentous fungi). Nearly 2550 species are covered by Biolog for identification.

Application

Clean room analysis for identification of microbes prevalent in environment, Industrial quality control in analysis of food and/or agricultural products, Plant disease diagnosis, Veterinary, Analysis of clinical samples including dangerous pathogens of human, animal & plant origin, Education & Research involving General & Applied Microbiology.

Principle & Methodology

Biolog Microbial Identification System is based on the theory that a species of bacteria develops a unique metabolic finger-print on a set of carbon sources and biochemicals. The cultured isolate is tested for utilization of different carbon sources, which are pre-filled and dried into a 96 well Microplate. Tetrazolium redox dyes are used to colorimetrically indicate utilization of the substrates.

- It is based on utilization pattern of different carbon sources and biochemicals.
- These carbon sources and biochemicals are prefilled and dried into a 96 well microplate.
- Microbial cells, if utilize the nutrient; respire and release energy.
- Cellular respiration is indicated by a proprietary Redox dye, Tetrazolium, which gets reduced to form a distinct purple colour.
- Unique metabolic profile is recorded for a given species, and compared with thousands of profiles stored in Biolog databases.
- Microbial species is identified

The Identification Process

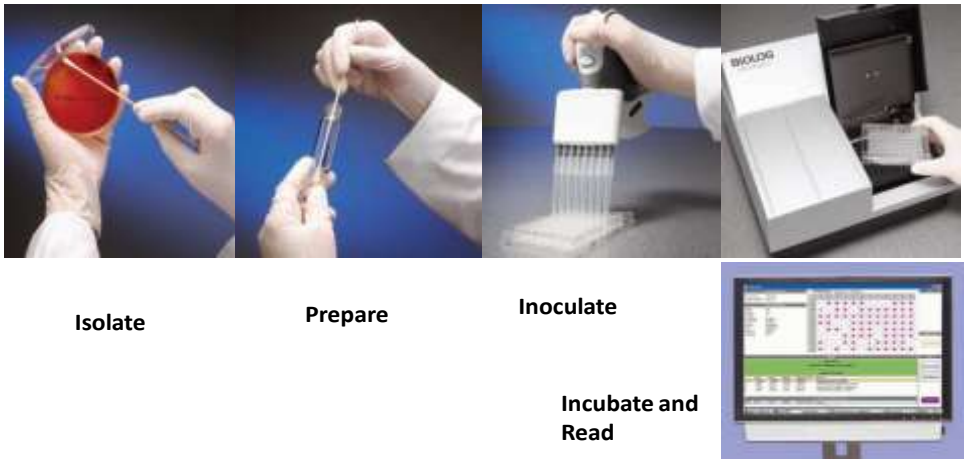
Microbial identification for GEN III MicroPlates involves four basic steps. The identification process for AN, YT, or FF MicroPlates involves five basic steps. These steps apply to all identifications. A small number of species have peculiarities that may require an extra step or

special handling techniques.

The Microbial Identification Process for GEN III MicroPlates

A simple, straightforward procedure.

1. Isolate a pure culture on agar media
2. Prepare inoculum at specified cell density
3. Inoculate the Biolog MicroPlate
4. Incubate the plate, observe and enter the reaction pattern to obtain ID result



The Microbial Identification Process for GEN II MicroPlates

Step 1: Isolate a pure culture on Biolog media

Isolating a pure culture is not always easy. For example: Bacteria often have sticky surfaces and cells sometimes stick together in clumps. As a first step to accurate microbe identification, streak agar plates using correct techniques to generate well isolated colonies. Always use Biolog-recommended culture media and growth conditions.

Step 2: Do a Gram stain and determine testing protocol

For bacteria, proper Gram stain technique and interpretation are the important second step in the ID process identification; use the wet prep test as necessary to differentiate yeasts from filamentous fungi.

Step 3: Prepare inoculum at specified cell density

Microbiologists are sometimes trained to prepare cell suspensions by judging cell density by eye. This practice will not yield accurate and reproducible results. Cell density determines oxygen concentration a key parameter to control when testing microorganisms in MicroPlates. In addition, Biolog has carefully optimized the required inoculating fluids.

Step 4: Inoculate and incubate MicroPlate

Pipette the specified amount of cell suspension into the MicroPlate, put the lid on, and incubate under the same conditions of temperature and atmosphere used to culture the microorganism. Biolog MicroPlates do not need oil overlays or color-developing chemicals.

Step 5: Read MicroPlate and determine ID

After an appropriate incubation time, read MicroPlates either by eye or using the

MicroStation Reader. In either case, the pattern formed in the wells is entered into the software, which searches the database and provides identification in seconds.

Data is fed into a software enabled computer which performs analysis and reports the species of the isolated micro-organism.

- A large sized database is comprised of ~2550 species of which ~700 are of clinical importance.
- Gen III Microplate can be used to identify 1350 species of **aerobic bacteria**.
- AN Microplate can be used to identify 361 species of **anaerobic bacteria**.
- YT Microplate can be used to identify 267 species of **yeast**.
- FF Microplate can be used to identify 619 species of **filamentous fungi** (619 species).
- GN2 Microplate can be used to identify species of **gram negative bacteria**.
- GP2 Microplate can be used to identify species of **gram positive bacteria**.
- Technology can be used in **manual, semi-automatically** or **fully automatically** as per the researcher's variable needs and budget.

Different Formats of Biolog System:

Gen III Microstation System (Most preferred system)

Microstation is a semi-automated microbial identification. It is Plate reader which is linked to a computer configured with software related to data collection and microbial identification software. It is capable of reading all types of Biolog Microplates. A microplate loaded with suspension of a test organism is incubated in a user-provided incubator and read using Microstation. The metabolic finger print is read and sent to the computer for recording and eventual comparative studies with profiles already stored in Biolog databases. Computer reports the species/genus when the metabolic finger print is matched with those present in Biolog Database. The system is capable of identifying aerobic bacteria, anaerobic bacteria, yeast as well as filamentous fungi.

System Benefits

No Gram-Stain, One test panel IDs both GN and GP bacteria, Set-up time in under a minute, **Accurate results** in as little as 4 hours, Powerful RetroSpect software for trending & tracking, 21 CFR part 11 compliant

Gen III Omnilog Id System (Preferred system for handling a large number of samples)

Gen III Omnilog Id System is an automated microbial identification system. It is provided along with Omnilog which is Plate reader cum Incubator. It is linked to a computer configured with software related to data collection and microbial identification software. A microplate loaded with suspension of test organism is incubated and read in Omnilog. The metabolic finger print is read and sent to the computer for recording and eventual comparative studies with profiles already stored in Biolog databases. Computer reports the species/genus when the metabolic finger print is matched with those present in Biolog Database. Omnilog can accommodate 50 Microplates simultaneously, with recording of the metabolic finger-print at 15 minutes interval in real-time thus

making the microbial identification automated and high throughput. The system is capable of automated identification of aerobic bacteria only. It can be upgraded to undertake Phenotype Microarray.

Gen III Omnilog Plus Id System

The system is capable of automated identification of aerobic bacteria, and rapid identification of anaerobic bacteria, yeast as well as filamentous fungi.

Gen III Microlog M System (Manual System)

Microlog M is the Manual Version of Biolog's Microbial Identification System. It uses the same Gen III plate and Gen III Microbial Identification software, as are used in automated systems. Difference is that Computer and Plate Reader, are not provided in Manual System. Microbial culture is used to inoculate the Gen III plate, which is then incubated in a lab incubator. Plate is read for all the 96 tests manually in terms of Positive or Negative reaction (If color appears, it is positive otherwise negative). The plate results (positive or negative), are fed manually in Gen III software which is provided and loaded in a user provided computer. Software does the analysis, searches Biolog provided database, and then reports the species. You can also update the database with those genus/species which are not present in Biolog database (using an optional Retrospect). Manual system can be used for only aerobic bacteria.

Eco-friendly Management of Diseases for Safe Storage and Export of Wheat

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Wheat along with rice are main stay of our national food security system. Major production of wheat is in R-W cropping system in Indo-Gangetic plains accupying about 10.5 mha. Annual food grain production in India is about 240 mt and out of which annual wheat production is about 83 mt. The target of wheat production at the end of Xth five year plan (2006-2007) was 104 mt, but production was less by 30 mt. The projected wheat requirement by 2020 is 109 mt, so additional production of 26 mt in the next nine year is to be achieved. Estimated losses of food grains is approx. 18 per cent (37 mt) due to diseases, weeds, insect pests and other factors.

In India, no other major crop has achieved a growth rate in production comparable to wheat. This may be attributed to new technological package comprising of high yielding varieties (HYV's), increased area under irrigated wheat, greater fertilizer consumption and extension of wheat cultivation to non-traditional regions. This has created an environment for rapid development and spread of diseases. Dwarf varieties, high dose of inorganic fertilizer, closer plantings, monocropping, staggered sowing, lack of tolerance to disease in new varieties, introduction of newer race of pathogen, unhygienic cropping sequence, etc. have contributed to change in pest status for the worse. In recent years, considerable shifts have occurred in the prevalence of wheat diseases in various parts of the country. Popularization of resistant varieties of zonal importance has helped to reduce losses caused by rusts. loose smut and karnal bunt have shown variable trends over years while leaf blights and powdery mildew have shown an increasing trend.

Wheat is affected by various diseases, the important being stem rust, leaf rust, stripe rusts loose smut, leaf smut, karnal bunt, hill bunt, common bunt, foliar blight or *Helminthosporium* blight or *Alternaria* blight, nematode disease by *Anguina tritici*, *H. avenae* (CCN) and powdery mildew. Out of these diseases, the rust are most devastating in absence of resistant varieties for different conditions as other measures are either not effective or non practical for resource poor farmers. Diseases which are caused by *Puccinia* spp. on winter cereals are leaf or brown rust, distributed throughout the country. These are of major concern in crop – health program. Yellow or stripe rust is important in the hills as well as the North-Western plains zone (NWPZ), especially in Punjab, parts of Haryana, foot hills of Himanchal Pradesh and Jammu and Kashmir and stem or black rust usually appears in southern parts of the country but it may appear rarely in NWPZ and very late in the season.

The new – virulent rust threatens world wheat with wide spread outbreak of new aggressive strains of yellow rust in Asia, Africa, and caused a loss of billions of dollars in 2010. News came in St. Petersburg meeting that four mutants of Ug99 had overcome two important

gene used in breeding program. First discovered in Uganda in 1998 the original strain has spread so far to Kenya, Ethiopia, Sudan, Yemen, and Iran. It threatens to move to other parts of Asia and Africa and potentially the entire world. About 90 percent wheat is considered susceptible to this stem rust and small scale farmers without access to fungicides are the most vulnerable.

Ug99 have virulence for Sr 31 gene incorporated from rye. Rigorous screening since 2005 of materials from 22 countries and International center has identified material with adequate resistance both race specific and adult plant type against high yielding background. The specific nature of Ug 99 carrying unique combination of virulence to known and unknown res. genes makes most of the American resistant material as susceptible. Predicting the migration path of Race Rg99 and most rust spores close to the sources and long distance (cross-continent) dispersal resulting in colonization of new regions is also known and long distance dispersal on travellers clothing is another element of colonization of new areas. (Yellow rust of Australia in 1979 from Europe). The second major mode of dispersal is stepwise range expansion and has much higher probability and third mode of dispersal is extinction and recolonization.

Resistant – Breeding differs from breeding for any other trait (qualitative and quantitative) which are consideration of the biology of the pest over and above the breeding system of crop plants, the type and genetics of resistance, the variability of pathogens in relation to host resistance (race specific and non specific resistance) is the major constraint in the process of breeding for disease resistance. Various ways for using strong resistance genes- single, deployment, in combination, multiline/mixtures. Distribution of varieties with different resistance gene in space (spatial gene deployment) and in time (temporal gene deployment). Gene deployment in space would be most effective against pathogens/ parasites that migrate over long distance and cycling against those that do not. By adopting such strategy live, the stabliizing selection could be switched on and off and directional selection is thus under human control and R-gene could be stored and used against at later date i.e. recycling of R-gene can be done. This sequential pattern involves regulator control of disease through changes from one R-gene to another. The proposed breeding system to minimize genetic vulnerability by manipulation of host resistance gene is to create directed selection in the pathogen, a three gene system of variety rotations to minimize genetic vulnerability by utilizing directed selection in the host to produce directed selection in the pathogen. Low incidence of stem rust in the winter sown wheat during 1981 and 1982 years at Wellington although there was severe incidence of stem rust in summer wheat crop in 1981 happened because of gene deployment. The other examples include, on stray crop in chickmanglur district of Karnataka in 1982 virulence on winter wheat 40A (62G 29), 21 A2 (75G5) and 117A (36G2) were most common during the 2 years period, differing in predominance in the 6 areas surveyed, virulence on summer nurseries 21A.2 (75 G5) at Dalang Maidan (H.P.) and 40A (62 G29) at Wellington (T.N.) constituted the major proportion of the virulence flora. The differential effectiveness of Sr genes reveal the scope for gene deployment like 2 gene combination for deployment for the management of stem rust of wheat in 4 ecological areas of

India. Bahadur and Nagaraja (1985) reported that leaf rust resistance Lr9, Lr 19 and Lr24 confirmed immunity and Lr10 was effective against majority of Indian isolates, this opened up the possibilities of planned gene deployment.

In Punjab, serious epidemics of leaf and stripe rust were avoided during 1976, 1983 and 1996. Serious epidemics of leaf and stripe rust occurred in the adjoining West Punjab (Pakistan) during 1975, 1983 and 1996 due to the lack of such approach. Brown rust epidemics can be checked by frequent cultivar changes both at the inoculum source and at the remote target areas. This type of spatial and temporal development of genes is a very effective and ecofriendly strategy of disease management. Aim of gene pyramiding are to increase the strength of vertical resistance by way of combining to such a point that the matching pathogen geneotypes lacks ability to over come the combined resistance, to increase the longevity of resistance due to low probability of mutation to multiple virulence. Pyramiding of genes for specific resistance may act in complementary or additive fashion and thus enhance the level of resistance shown by one particular genes separately.

Gene pyramiding strategy for controlling different diseases of crop have been used successfully. Various problems are encountered in developing a variety with combined resistances as many of the desired resistance genes are allelic or closely linked and so can not be easily combined as the source of different resistance gene will be different host plants which may create breeding problems or the isolated advanced line may have undesirable character linked with resistance gene. The development and cultivation of varieties with multi genes for resistance may lead to the development of super race sooner. Both gene (Lr 19 and Lr 24) were introgressed from donor genotypes in to acceptor genotype by marker-assisted introduction MAI method. The presence of Lr 19 gene in donors and offspring's was detected by the null endopeptidase allele Ep-D1C at the loci Ep DI. The presence at Lr 24 gene was analysed by the sequence tagged sites marker and F_2 and F_3 progenies were obtained and individual plants possessing molecular marker linked with both desired resistance gene were selected. The obtained biological material may be included in our wheat breeding programmes.

Gene pyramiding for yellow rust resistance gene, Yr5, derived from *Triticum spelta* shows immunity or high resistance to the most popular isolates Tiaozhong 30 and 31 in China. Since the Yr 5 gene was cytologically located on the long arm of chromosomes 2B, By33, the donor Yr-5, was crossed and back crossed with the susceptible line 441, and BC 3F2 and BC3 F3 segregating population were screened from polymorphism by using 11 micro-satellite primers mapped on chromosomes 2B. A marker Xgwn 501-195 bp/160 bp, was found to be linked to Yr 5, with a genetic distance of 10.5-13.5 cm.

Multilines/mixtures for genetic variability in host population can reduce the fitness of the pathogens and thus can break the boom-burst cycle.

Machanisms of disease control in mixture/multilines are interception of spore by resistance plant called barrier effect, reduction in density of susceptible host variety and the consequent

spore production and transmission, induced resistance (due to the non-virulent pathogen cross protection), competitive inhibition, modification in micro-climate due to different plant types.

Pre emptive breeding or anticipatory breeding for resistance is breeding for resistance to future pathotype. It's success depends on the ability of the breeder to predict the likely pathogen phenotypes (parthotypes) that will be important at some future time because durability of resistance can not be assured, resistance breeding strategies are usually supported with the maintenance of genetic diversity to provide buffering against extreme crop losses in the event of significant pathogenic changes.

Durable resistance is advocated to avoid boom and burst cycle use of durable resistance. When a pathogen is not able to overcome the host resistance easily due to fitness reasons, the host stage is delayed and resistance is noted as durable. This type of resistance remains effective, though the variety is grown over a long period of time. Wheat varieties like HD 2189 HP 1102, DL 153-2, DL-803-3 and DL 802-3 which posses Lr 34 with other gene combinations have a good degree of resistance and thus have become popular with the growers. Wheat variety Thatcher and Lee have withstood stem rust for 55 and 30 years, respectively, Capple Desprez expresses a moderate resistance to yellow rust at adult stage which has gene, Lr34 (for resistance to leaf rust) and Sr.2 (for resistance to stem rust) have been recognized for durability.

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VALEDICTORY ADDRESS

by

Vice-Chancellor

G.B. Pant University of Agriculture & Technology, Pantnagar- 263 145

on

December 02, 2011

It is my great privilege and honour to be here at the valedictory function of the Training Course on "Quality Management and Plant Protection Practices for enhanced competitiveness in agricultural export" organized by the Centre of Advanced Faculty Training (CAFT) in Plant Pathology. I am delighted to know that 14 scientists from the 7 states of the country participated in the training course. I am sure you will be satisfied with the contents and various arrangements of the training programme. By this time you might have realized the accomplishments of this Department which was founded and headed by two giant plant pathologists, Dr. Y.L. Nene and Dr. R.S. Singh, who gave inspiring leadership not only to the Department of Plant Pathology during early 1960s soon after the establishment, but also to the University. This department has to its credits considerable number of research publications and several books have been published by most reputed national and international publishers.

I am happy that under the dynamic leadership of Dr J. Kumar this department has maintained the rich traditions of their fore fathers.

India is one of the fastest growing economies of the world and is currently the focus of a great deal of international attention. It is the seventh largest country in the world in terms of its geographical size. Indian economy is basically agrarian as two thirds of country's workforce of the country still dependent on agriculture for its lively hood in form or another. The past accomplishments of this sector are a great strength to face the current problems and future challenges in the areas of greater efficiency (competitiveness), sustainability, poverty alleviation and continued food self-sufficiency. With trade liberalisation, agricultural exports have also become an important national goal. The present goals of Indian agriculture warrant reformation of strategies and action plans. Agricultural exports increased from about 600 million US dollars in 1960-61 to 3520 million US dollars in 1990-91. During post economic reforms period, the value of agricultural exports has nearly doubled. Commodities such as marine products, oil meals, rice, coffee, tea, spices, cashew, tobacco, castor oil, groundnut, sesame, fresh fruits, vegetables, pulses etc., are important export earners and are being exported to more than 110 countries. While India holds an important position in the export market for a set of traditional agricultural commodities, new

areas and new commodities are likely to emerge.

The Indian agriculture export strategy should be to strengthen and widen for established 'commercial commodities' like tea, coffee, spices, cotton, jute, sugar, oil meals etc., and also to create and capture new export market for 'dynamic commodities' like meat, dairy products, poultry, fishery products, vegetables, fruits, floriculture etc., whose demand in the international market is tremendous. India has a comparative advantage in many of these commodities due to availability of varied agro-climatic conditions, diversified commodity mix and low wage rates leading to lower cost of production etc. But stricter control processes under Sanitary and Phytosanitary Agreement and other non-tariff barriers should well taken care off.The European Union is our largest trading partner accounting for about 21% of total Indian trade but trade with neighboring countries is growing fast.

Agricultural commodities represent around one third of the total agricultural export, while intermediate products over one quarter and final products account for the remaining quarter. In order to expand our share in international trade we have to give more thrust on the processed food, which are in great demand in developed countries. The milled rice, cotton and wheat, are also still the main commodity within the top exports.

The big challenge before the country is to encourage the exports of processed food products and the compliance of SPS Agreement. In the recent past awareness regarding importance of health measures and fear of health hazard has shown a definite upward trend. As a result an elaborate system of inspection and certification has evolved over the years. This system becomes more rigorous if the goods in question are to be sent to foreign markets. Yet imposition of more stringent SPS standards by the developed world would definitely have some repercussions on the trade of developing countries, including India. Some promising export-commodities for India like coffee, pulses, spices etc. may have to comply with certain stricter rules and regulations. In this context, no doubt the present course organized by the Centre of Advanced Faculty Training in Plant Pathology was very timely to deal with a field of study which has largely been neglected in India. I am sure the scientists participating in this course will effectively utilize the knowledge earned not only in doing research and teaching but also to find out ways and means of transferring the technology to the end users. I must congratulate the faulty of Centre of Advanced Faculty Training in Plant Pathology for meticulous planning and well organization of this training course and also to the participants for successfully completing the training course.

I wish you all the best.

"Jai Hind"

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ANNEXURE-I

CENTRE OF ADVANCED FACULTY TRAINING IN PLANT PATHOLOGY
College of Agriculture, Pantnagar-263 145 (Uttarakhand)

Following committees have been constituted for smooth conduct of the training programme on "Quality Management and Plant Protection Practices for enhanced competitiveness in agricultural export" scheduled on November 12 to December 02, 2011.

1. Overall Supervision

Dr. J. Kumar, Director CAFTPP
Dr. R.P. Singh, Course Coordinator
Dr. H.S. Tripathi
Dr. R.P. Awasthi
Dr. V.S. Pundhir
Dr. (Mrs.) K. Vishunavat

2. Invitation, Inaugural and Closing Function Committee

Dr. H.S. Tripathi– Chairman
Mr. Narender Singh
Mr. S.P. Yadav
Mr. Mani Ram

3. Inaugural Session, Intersession Tea and valedictory function Committee

Dr. K.P.S. Kushwaha – Chairman
Dr. (Mrs.) Deepshikha
Mr. S. P. Yadav
Mr. Jagannath

4. Budget Committee

Dr. R. P. Awasthi – Chairman
Dr. Yogendra Singh
Mr. Varshney (A.A.O.)
Mr. A. B. Joshi
Mr. Praveen Kumar
Mr. Het Ram

5. Transport and Reception Committee

Dr. Pradeep Kumar – Chairman
Mr. Prakash Joshi
Mr. P.C. Khulbe
Mr. Bhupesh Kabadwal

6. Boarding & Loading Committee

Dr. V.S. Pundhir – Chairman
Dr. R.K. Bansal
Mr. S. P. Yadav

7. Registration Committee

Dr. (Mrs) K. Vishunavat – Chairperson
Dr. (Mrs.) Kanak Srivastava
Dr. (Mrs.) Renu Singh

8. Session Arrangement Committee

Dr. S.C. Saxean – Chairman
Dr. A.K. Tewari
Mr. Prakash Joshi
Mr. Vikram Prasad

9. Field / Excursion Trip Committee

Dr. R.K. Sahu – Chairman
Dr. Vishwanath
Mr. M.K. Sharma
Mr. K. S. Bisht
Mr. R. B. Sachan

10. Audiovisual Aid & Publicity Committee

Dr. A.K. Tewari-Chairman
Mr. R.C. Singh
Mr. Bupesh Kabdwal

11. Committee for typing correspondence work

Dr. K.S. Dubey, Chairman
Smt. Meena Singh
Mr. Gharbharan Prasad
Mr. Mehboob

ANNEXURE-II

LIST OF PARTICIPANTS

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2.	Dr. Ashim Kumar Mishra Jr. Scientist-cum-Assistant Professor Department of Plant Pathology Tirhut College of Agriculture (Rajendra Agricultural University) Dholi, Muzaffarpur- 843 121 (Bihar)	(O): 0621-2293227 (Mb.): 9973218436 E-mail: ashim_sigatoka@yahoo.com
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S U M M A R Y

Sl. No.	State	No. of participants
1	Arunachal Pradesh	01
2	Bihar	02
3	Chhattisgarh	01
4	Madhya Pradesh	03
5	Maharashtra	01
6	Rajasthan	01
7	Uttarakhand	05
	Total Participants	**14**

ANNEXURE-III

TRAINING

ON

QUALITY MANAGEMENT AND PLANT PROTECTION PRACTICES FOR ENHANCED COMPETITIVENESS IN AGRICULTURAL EXPORT

(November 12 to December 02, 2011)

Venue	Conference Room, International School of Agriculture
Sponsored by	Centre of Advance Faculty Training in Plant Pathology (ICAR, New Delhi)

GUEST SPEAKERS/CONTRIBUTORS

Dr. Y.L. Nene	Chairman, Asian Agri-History Foundation, Secunderabad (AP)
Dr. D.V. Singh	Former Head, Div. of Plant Pathology, IARI, C-14D MIG Flats, Vatika, Apartment, Maya Puri, New Delhi
Dr. Rakesh Pandey	Scientist, Central Institute of Medicinal &Aromatic Plants (CIMAP), Near Kukrail Picnic Spot, Lucknow (UP)
Dr. J.P. Singh	Dy. Director (E), National Plant Quarantine Station, Rangpuri, New Delhi
Dr. Yatin J. Mokal,	Dy. GM Cheminova, Mumbai
Dr. Henerik G. Schlosser	Cheminova, Denmark
Dr. D.B. Parekh	Principal Scientist (Plant Pathology), Division of Plant Quarantine, National Bureau of Plant Genetic Resources, Pusa Campus, IARI, New Delhi
Dr. Kavita Gupta	Sr. Scientist (Plant Pathology), Division of Plant Quarantine, National Bureau of Plant Genetic Resources, Pusa Campus, IARI, New Delhi
Dr. Y.P. Singh	Principal Scientist, Forest Pathology Division, Forest Research Institute, Dehradun

LOCAL SPEAKERS

Dr. J.P. Pandey	Director, Experiment Station
Dr. J. Kumar	Dean, College of Agriculture
Dr. P.S. Bisht	Dean, Hill Campus Ranichauri
Dr. J. Kumar	Professor and Head-cum-Director CAFT Plant Pathology
Dr. S.C. Saxena	Honorary Professor, Plant Pathology
Dr. K.P. Singh	Emeritus Scientist, Plant Pathology

Dr. H.S. Tripathi	Professor, Plant Pathology
Dr. R.P. Awasthi	Professor, Plant Pathology
Dr. (Mrs.) K. Vishunavat	Professor, Plant Pathology
Dr. V.S. Pundhir	Professor, Plant Pathology
Dr. R.K. Sahu	Professor, Plant Pathology
Dr. Vishwanath	Assoc. Prof., Plant Pathology
Dr. R.P. Singh	Assoc. Prof., Plant Pathology
Dr. K.P.S. Kushwaha	SRO, Plant Pathology
Dr. Y. Singh	SRO, Plant Pathology
Dr. A.K. Tewari	SRO, Plant Pathology
Dr. V.P. Singh	Professor, Agronomy
Dr. M.A. Khan	Professor & Head, Entomology
Dr. S.N. Tewari	Professor, Entomology
Dr. Ruchira Tewari	Assistant Professor, Entomology
Dr. H.S. Chawla	Prof. & Head, Genetics and Plant Breeding
Dr. Shivendra Kashyap	Assoc. Professor, Agriculture Communication
Dr. Anil Kumar	Professor and Head, MBGE
Dr. Anil Sharma	Assoc. Prof., Biological Science
Dr. A.K. Pant	Professor & Head, Chemistry
Dr. Anupma Singh	National Fellow, Post Harvest Engineering
Dr. Anjana Srivastava	Asstt. Professor, Chemistry
Dr. Balwinder Singh	Assoc. Prof., Vet. Anatomy
Dr. K.P. Singh	Professor, Hill Campus Ranichauri

ANNEXURE-IV

CENTRE OF ADVANCED FACULTY TRAINING IN PLANT PATHOLOGY
G.B. Pant University of Agric. & Tech., Pantnagar-263 145 (UK)
Course Schedule (November 12 to December 02, 2011)

"Quality Management and Plant Protection Practices for Enhanced Competitiveness in Agricultural Export"

Venue : Conference Room, International School of Agriculture

Day & Date	Time	Topic (Lecture/ Lab)	Speaker/Contact
Saturday Nov. 12	09:15-10:00 hrs	Registration & Introduction with Plant Pathology Faculty Venue: PG Lab, Plant Pathology	Registration Committee & Faculty Plant Path.
	10:00-11:00 hrs	Inaugural Function Venue: Conference Hall, Agriculture College	
	11:00-11:15 hrs	Tea break	
	11:15-13:00 hrs	College of Agriculture at a Glance	Dr. J. Kumar, Dean Agriculture
	13:00-14:30 hrs	Lunch	
	14:30-17:00 hrs	Visit of different research centre of the university	Dr. Vishwanath
Sunday Nov. 13	08:00 hrs	Cricket Match of faculty and trainees with students of the Plant Pathology Department Venue: Stevenson Stadium	
Monday Nov. 14	09:30-11:00 hrs	Standard operational practices for methyl bromide fumigation to exportable commodities	Dr. J.P. Singh, Dy Director, DPPQ&S
	11:00-11:15 hrs	Tea Break	
	11:15-12:45 hrs	Quarantine requirements for agricultural exports	Dr. J.P. Singh, Dy Director, DPPQ&S
	12:45-14:30 hrs	Lunch	
	14:30-15:00 hrs	Designing of cooling room facility for post harvest handling at small scale	Dr. J.P. Pandey, DES
	15:00-15:30 hrs	Safe use of pesticides for quality management	Y. J. Mokal, Dy. GM Cheminova, Mumbai
	15:30-15:45 hrs	Tea Break	
	15:45-17:00 hrs	Global prospect on quality management in plant protection	H.G. Schlosser, Cheminova, Denmark
Tuesday Nov. 15	09:30-11:00 hrs	Department of Plant Pathology and CAFT activities at Pantnagar	Dr. J. Kumar, Director, CAFT
	11:00-11:15 hrs	Tea Break	
	11:15-12:45 hrs	Teaching plant pathology in India	Dr. H.S. Tripathi
	12:45-14:30 hrs	Lunch	
	14:30-15:30 hrs	Econ-friendly management of diseases for safe storage and export of wheat	Dr. K. P. Singh
	15:30-15:45 hrs	Tea break	
	15:45-17:30 hrs	Visit to Plant Pathology Labs and interaction with faculty	Dr. R.P. Singh

Wednesday Nov. 16	09:30-11:00 hrs	Pest risk analysis: A case study karnal bunt of wheat	Dr. D.V. Singh
	11:00-11:15 hrs	Tea Break	
	11:15-12:45 hrs	Role of post harvest handling operations & machines in maintaining seed quality	Dr. Anupma Singh, National Fellow, PCT
	12:45-14:30 hrs	Lunch	
	14:30-15:30 hrs	Pest risk assessment for quarantine pests	Dr. V.S. Pundhir
	15:30-15:45 hrs	Tea Break	
	15:45-17:30 hrs	Visit to KNSCCF	Dr. K.P.S. Kushwaha
Thursday Nov. 17	09:30-17:00 hrs	Participation in University Foundation day lectures Venue: University Auditorium (Gandhi Hall)	Dr. R.P. Singh
Friday Nov. 18	09:00-11:00 hrs	Impact of seed borne diseases on international trade	Dr. K. Vishunavat
	11:00-11:15 hrs	Tea Break	
	11:15-12:45 hrs	Participation in University Foundation day lectures Venue: University Auditorium (Gandhi Hall)	Dr. R.P. Singh
	12:45-14:30 hrs	Lunch	
	14:30-15:30 hrs	Participation in University Foundation day lectures Venue: University Auditorium (Gandhi Hall)	Dr. R.P. Singh
	15:30-15:45 hrs	Tea Break	
	15:45-17:30 hrs	Organic farming in Asian in India	Dr. Y.L. Nene
Saturday Nov. 19	09:30-11:00 hrs	Visit to MRTC and Bio-control lab	Drs. K.P.S. Kushwaha & R.P. Singh
	11:00-11:15 hrs	Tea Break	
	11:15-12:45 hrs	Visit of Rhizosphere lab	Dr. Anil Sharma, CBSH
	12:45-14:30 hrs	Lunch	
	14:30-15:30 hrs	Soil solarizations- An eco-friendly disease management strategy.	Dr. Y. Singh
	15:30-15:45 hrs	Tea Break	
	15:45-17:30 hrs	Isolation, screening and delivery methods of Trichoderma for the management of plant diseases to produce quality foods under organic farming	Dr. A.K. Tewari
Sunday Nov. 20	9:30 hrs	Visit of Indo-dutch project, Chafi, Bhimtal/Research Centre Patuwadangar/ARIS Nainital	Drs. R.K. Sahu/ M.K. Sharma
Monday Nov. 21	09:30-11:00 hrs	Role of plant pathology in food security	Dr. J. Kumar
	11:00-11:15 hrs	Tea Break	
	11:15-12:45 hrs	Alternatives to methyl bromide	Dr. S.N. Tewari
	12:45-14:30 hrs	Lunch	
	14:30-15:30 hrs	Eco-friendly management of diseases for safe storage and export of Oilseed	Dr. R.P. Awasthi
	15:30-15:45 hrs	Tea Break	
	15:45-17:00 hrs	Molecular identification methods for detection of karnal bunt of wheat (Practical session)	Dr. Anil Kumar, MBGE

Tuesday Nov. 22	09:30-11:00 hrs	Weed management in relation to human and environmental health	Dr. V.P. Singh
	11:00-11:15 hrs	Tea Break	
	11:15-12:45 hrs	Eco-friendly management of diseases for safe storage and export of Maize	Dr. S.C. Saxena
	12:45-14:30 hrs	Lunch	
	14:30-15:30 hrs	Advances in electron microscopy and application in plant pathology	Dr. Balwinder Singh
	15:30-15:45 hrs	Tea Break	
	15:45-17:00 hrs	Practical session on Electron Microscopy	Drs. Balwinder Singh & M.P. Singh
Wednesday Nov. 23	09:15-09:30	Group photograph	
	09:30-11:00 hrs	Role of plant parasitic nematodes in post harvest losses of field and horticultural crops	Dr. Rakesh Pandey, CIMAP, Lucknow
	11:00-11:15 hrs	Tea Break	
	11:15-12:45 hrs	Problem of mycotoxins and their impact on food export	Dr. A.K. Pant
	12:45-14:30 hrs	Lunch	
	14:30-15:30 hrs	HPLC: An important tool for assessment of pesticides residue in exportable commodities	Dr. Anjana Srivastava
	15:30-15:45 hrs	Tea Break	
	15:45-17:00 hrs	Pesticides residue analysis through HPLC (Practical)	Dr. Anjana Srivastava
Thursday Nov. 24	09:00 hrs.	Departure to Ranichauri	
Friday Nov. 25	09:30-11:00 hrs	Academic activities at Hill Campus	Dr P.S. Bisht
	11:00-11:15 hrs	Tea Break	
	11:15-12:45 hrs	Post harvest management of diseases of temperate fruits	Dr. K.P. Singh
	12:45-14:30 hrs	Lunch	
	14:30-17:00 hrs	Visit of IPM Demonstrations at Farmers field.	Drs. K. P. Singh/Vijendra Kumar
Saturday Nov. 26	07:30 hrs	Departure for Dehradun	
	10:30-13:00 hrs	Visit of Forest Research Institute	Dr. Y.P. Singh, FRI
	13:00-14:00 hrs	Lunch	
	14:00 hrs	Departure from Dehradun	
	15:00-16:00 hrs	Visit to flax foods	
	16:00 hrs	Departure for Pantnagar	
Sunday Nov. 27	09:30-12:45 hrs	Library visit	Dr. R.P. Singh
	12:45-14:30 hrs	Lunch	
	14:30-15:30 hrs	Certification of temperate fruit crops' planting material against viruses for high productivity and quality	Dr. D.B. Pareekh, NBPGR
	15:30-15:45 hrs	Tea Break	

	15:45-17:00 hrs	Discussion with Participants	
Monday Nov. 28	09:30-11:00 hrs	Econ-friendly management of diseases for safe storage and export of Rice	Dr. J. Kumar
	11:00-11:15 hrs	Tea Break	
	11:15-12:45 hrs	Eco-friendly management of diseases for safe storage and export of Potato	Dr. V.S. Pundhir
	12:45-14:30 hrs	Lunch	
	14:30-17:00 hrs	Communication skills for teaching professionals (Practical session)	Dr. Shivendra Kashyap
Tuesday Nov. 29	09:30-11:00 hrs	Implication of SPS agreement on agricultural trade	Dr. Kavita Gupta, NBPGR
	11:00-11:15 hrs	Tea Break	
	11:15-12:45 hrs	Storage pests of exportable crops	Dr. Ruchira Tewari
	12:45-14:30 hrs	Lunch	
	14:30-15:30 hrs	Disinfection protocols for facilitating trade in fruits and vegetables	Dr. Kavita Gupta, NBPGR
	15:30-15:45 hrs	Tea Break	
	15:45-17:00 hrs	Practical on detection of seed borne plant pathogens	Dr. K. Vishunavat
Wednesday Nov. 30	09:30-11:00 hrs	Standard operating procedure for export inspection and phytosanitary certification of plants.	Dr. J. Kumar
	11:00-11:15 hrs	Tea Break	
	11:15-12:45 hrs	Econ-friendly management of diseases for safe storage and export of Pulses	Dr. H.S. Tripathi
	12:45-14:30 hrs	Lunch	
	14:30-15:30 hrs	Potential and problems in export of precious product of Apiculture	Dr. R.K. Thakur, YSPUHF, Solan
	15:30-15:45 hrs	Tea Break	
	15:45-17:00 hrs	Problem and prospect of Basmati Rice export	Ashok Agrawal, KLA, Rudrapur
Thursday Dec. 01	09:30-11:00 hrs	Post harvest problems of onion and garlic and its management for export	Dr. R.P. Singh
	11:00-12:30 hrs	Presentation by the participants	
	12:30-14:30 hrs	Lunch	
	14:30-15:30 hrs	Post harvest management of vegetables for export	Dr. R.P. Singh
	15:30-15:45 hrs	Tea Break	
	15:45-17:00 hrs	Presentation by the participants	
Friday Dec. 02	09:30-10:00 hrs	Evaluation of the training and feed back by participants	Dr. R.P. Singh
	10:00-11:00 hrs	Closing function	
	11:00-11:15 hrs	Tea Break	
	11:15-12:45 hrs	Botanicals in the management of storage pests	Dr. M.A. Khan
	12:45-14:30 hrs	Lunch	
	14:30-15:30 hrs	Status and prospects of India's trade in world agricultural	Dr. R.P. Singh
	15:30-15:45 hrs	Tea break	
	15:45-17:00 hrs	Discussion with Plant Pathology Faculty	