Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 02, Issue: 02 (MAR-APR, 2022)
Available online at http://www.agriarticles.com

Plant Health Management

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Plant health management is the science and practice of understanding and overcoming the succession of biotic and abiotic factors that limit plants from achieving their yield and quality, and reduce resource-use efficiency. Disease-related crop losses have been estimated to be between 15 and 30 per cent of total crop production. Improved crop protection strategies to prevent such damage and loss can increase production and make a substantial contribution to food security. Plant health management (PHM) is a cornerstone of field and horticultural crop production: strategies include sanitation, clean stock, host resistance, and control through biological, cultural, environmental, chemical, and regulatory means. Bio control is a crucial component of PHM. Pesticides employed to combat disease constituted an unjustifiable threat to biological systems, killing not only the target pathogen but also beneficial living organisms. New bio control and chemical products continue to improve control while meeting the requirement for minimal environmental impact. Continual introduction of new crops and new production technologies creates new opportunities for pathogens to exploit, such that new plant health or disease management tactics must be discovered and old ones rediscovered to achieve optimum health management for crops.
Key words: Bio control, Plant health management, Pesticides

Introduction

Plant Health management is the science and practice of understanding and overcoming the succession of biotic and abiotic constraints; that limit plants from achieving their full genetic potential as crops, ornamentals, timber trees or other uses.

Comparison between PHM and IPM

PHM, as a concept is younger than concept of IPM and is supplement to the IPM but not a replacement for IPM. In PHM all causes / constraints e.g. biotic and abiotic, crop yield, appearance, utility quality of the produce for end users are being taken into consideration. Whereas, IPM arose mainly in response to need to protect crops from pests / diseases.

Four Fronts in PHM

a] Use of clean planting materials

- Diseases can be managed successfully by cleaning up the planting material.
- Use of disease free seeds or planting materials

b] Clean soil and Root Health Management

- Crop rotation helps to improve root health management and density of roots (Wilt and root rots)

c] Clean, high quality irrigation water

- Pathogen infested water - problem for green house grown crops

- Develop salt tolerant transgenic crops

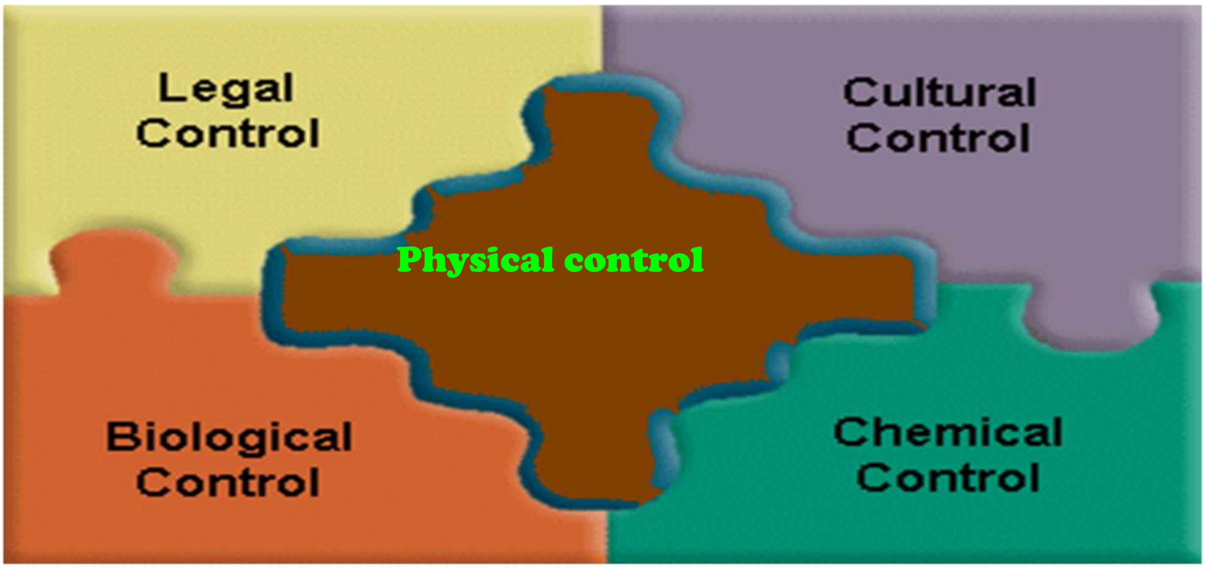
d] Protection of the crop against threatening diseases / hazards

- Management of foliar pathogens on the basis of epidemiology (Zadoks and Vanden Bosch, 1994), aerobiology (Aylor, 1998) and disease prediction and decision support systems

PHM / crop protection strategies being adopted successfully in agriculture are

Sr. No.	PHM Measures	Methods Involved
A.	Legal	Plant quarantine or Legislative measures
B.	Physical	Hot water / air treatment, radiation, flooding, fire and flame.
C.	Cultural	Tillage, Field/Plant sanitation, Crop nutrition, Crop rotation, Disease free seeds/ planting material, Adjustment of sowing / planting time, Intercropping
D.	Epidemiological approaches	Computer simulation models, Disease Forecasting Systems
E.	Bio-Control	a) Exploitation of antagonistic microorganisms b) Exploitation of PGPR c) Phyto extracts / plant base products d) VAM fungi as Bio- Control Agents
F.	Chemical	Inorganic, Organic, Synthetic and Natural
G.	Host Plant Resistance	Resistant/Tolerant varieties
H.	Immunization/Improvement of Host Plant Resistance	Cross protection, Induced resistance (SAR and ISR)
I.	Development of Transgenic Plants	Coat protein mediated resistance, R Gene mediated resistance, PR proteins
J	Biotechnological approaches	Meristem culture and Somaclonal variations, Use of Alien genes, Gene pyramiding, Gene Cloning, Transgenics

Plant Health Management / Crop Protection Strategies



A. Legal Control

Plant quarantine or Legislative measures

Quarantine may be defined as "the restriction imposed by duly constituted authorities on the production and movement of plant materials or animals or animal products or any other materials or normal activity of persons which is brought about under regulations in order to prevent introduction/ spread of pest to avoid losses."

First quarantine regulation

- **USA [1912] Fedral Plant Quarantine Act**
- **Destructive Insect Pest Act [DIPA] in India [1914]**

Success stories of legislative / Plant quarantine measures in India

- Export and transport of banana plants or any *Musa* sp. prohibited from Assam, Kerala, Orissa and west Bengal to other states of the country.
- Banana Mosaic : Transport of banana from Maharashtra and Gujrat is prohibited.
- Potato wart : Export of tubers from West Bengal to any other state or territory of India is prohibited.
- Mango grafts from North India are prevented to avoid mango malformation.
- Apple Scab : Transport of apple from Jammu and Kashmir and Himachal Pradesh is prohibited.
- Potato cyst nematode : Movement of potato from Tamil Nadu is prohibited.

B. Physical Measures

Method	Crop	Disease	Causal organism	Treatment
Hot water treatment	Wheat	Loose smut	*Ustilago tritici*	52^0C for 11 min
	Sugarcane	Red rot	*Colletotrichum falcatum*	54^0C for 8 h
	Sugarcane	Ratoon stunting	*Clavibacter xyli*	50^0C for 3 h
	Potato	Mosaic	*PVY, PVX*	20 min treatment each days at 52^0C
Hot air treatment	Sugarcane	Red rot	*Colletotrichum falcatum*	54^0C for 8h
	Sugarcane	Grassy shoot	*MLO*	54^0C for 8h
Flooding	Banana	Panama wilt	*Fusarium oxysporum f.sp. cubense*	To create anaerobic condition
	Rice	White tip	*Aphelenchoides besseyi*	
Fire and flame	Wheat and Oat	Leaf blotch	*Septoria spp.*	Burning and destruction
	Wheat	Take all of wheat	*Gaeumannomyces graminis*	
	Rice	Sheath blight	*Rhizoctonia solani*	
Solar Heat	Wheat	Loose smut	*Ustilago tritici*	Inactivation and destruction of the pathogen
Soil solarization (Katan, 1976)	Many crops	Soil borne pathogens (wilts, damping off, blight, rots)	*Fusarium, Pythium, Phytophthora, Rhizoctonia*	Hydrothermal process during hot summer months

Source: Singh *et al.*, 2000

C. Cultural Measures

Tillage

- Deep ploughing to expose the propagules to natural heating and desiccation.
- Tillage affects biological activities in the soil and helps in reducing the soil borne pathogens.

Field / plant sanitation

- Removal of diseased plants, plant parts or plant debris from the field and burning or burying deep in soil.
- e.g. Downy mildew, blight, leaf spot, anthracnose, cankers, fruit rots, rusts etc.

Crop nutrition

- Excessive nitrogen dosages tend plants to succumb pest and diseases.
- High dose of Potassium reduces incidence of diseases.

Crop rotation

Follow two to three years crop rotation

e.g- Cotton wilt - Paddy
Red gram wilt - Paddy
Potato brown rot - Wheat

Disease free seeds / planting materials

e.g. Sugarcane : Red rot, whip smut and grassy shoot.
Potato : Brown rot, wart, Black scurf and viral diseases

Adjustment of sowing / planting time

e.g. Planting potato during Feb-June, escapes the crop from late blight (*Phytophthora infestans*)

Epidemiology and Disease Forecasting

Epidemiology is the study of disease epidemics and factors affecting its outbreak (Temperature, Relative humidity, Rainfall, Light)

Epidemic disease : The spread of disease over a large geographical area within a short period of time.

D. Plant Disease Forecasting

Computer simulation models developed for Plant disease forecasting systems

Forecast programme	Diseases	Pathogen
EPIDEM (1969)	Early blight of potato	*Alternaria solani*
EPIMAY	Southern leaf blight of maize	*Helminthosporium*
EPICORN	Southern corn blight	*Helminthosporium maydis*
CERCOS	Blight of celery	*Cercospora* spp.
MYCOS	Blight of Chrysanthemum	*Mycosphaerella* spp.
EPIVEN	Apple Scab	*Venturia inequalis*
EPIDEMIC	Stripe rust	*Puccinia striiformis*
TOM-CAST	Early blight of tomato	*Alternaria solani*
PLASMO	Downy mildew of grapes	*Plasmopara viticola*
EPIVET	Viral diseases of potato	Contact and aphid transmitted viruses
EPIPIRE	Cereal rusts and aphids	*Puccinia graminis tritici*
BLITECAST	Late blight of potato	

Congenial environmental conditions for key diseases

Disease	Weather conditions
Late blight of potato	Optimum temperature for growth of fungus mycelium (16-18^{0}C), sporulation (9-26^{0}C), growth of germ tube (21-24^{0}C), and sporangial germination is 12-13^{0}C (zoospores). Night temperature below dew point for 4 hours; minimum temperature of 10^{0}C or slightly above; clouds on the next day and rainfall during next 24 hours
Bacterial blight of rice	Rainy weather, strong winds and 22-26 ^{0}C temperature
Rice blast	Nycto-temperature ranging from 20-24^{0}C in association with 90 % RH or above lasting for a week.

E. Biological Control

Biological control is the reduction of inoculum density or disease producing activities of a pathogen or parasite in its active or dormant state by one or more organisms, accomplished naturally or through manipulation of the environment, host or antagonist or by mass introduction of one or more antagonists (Cook, 2012).

Biological Control Involves

- Destruction of the propagative units or biomass of the pathogen.
- Prevention of inoculum formation.
- Weakening or displacement of the pathogen in infested residues.
- Reduction of vigour or virulence of the pathogen by agents such as mycoviruses or hypovirulence determinants.

Antagonists/bio-control agents commercially exploited for ecofriendly and economical management of diseases

Diseases/Pathogens	BCA product	BCA involved
Crown gall (*A. tumefaciens)*	Galltrol and Agrocin 84	*Agrobacterium radiobacter* strain 84
Crown gall (*A. tumefaciens*)	No gall	*Agrobacterium radiobacter* strain K1026
Phytophthora Pyhium, Fusarium, Rhizoctonia	Companion	*Bacillus subtilis* strain GB03
Fusarium, Rhizoctonia, Aspergillus	HiStick N/T	*Bacillus subtilis* strain MB1600
Pythium, Fusarium, Rhizoctonia, Nematodes	Deny	*Burkholderia cepacia*
Pythium, Rhizoctonia	Dagger G	*Pseudomonas fluorescens*
Fusarium (Barley) leaf spot (oat)	Cedomon	*P. chlororaphis*
Fire blight (*Erwinia amylovora)*	Herbicolin	*Pantoea agglomerans* C9-1
Powdery mildews	AQ 10 biofungicide	*Ampelomyces quisqualis* M-10
Botrytis, Penicillium	Aspire	*Candida oleophila* I-182
Fusarium oxysporum	Biotrox C, Fusaclean	*Fusarium oxysporum* (non-pathogenic)

F. Chemical Measures

- Different groups of chemicals / fungicides have developed after the discovery of Bordeux mixture by Millardet in 1885 for the control of downy mildew of grapes in France.
- Beginning with copper fungicides, there came in use, iron and mercury salts, then inorganic sulphur followed by organic sulphur.
- In the middle of 1960 the systemic fungicides starting with oxathins (carboxin), benzimidazoles, thiophanates, organophosphorus, triazoles and phenylamides have became very popular for control of the diseases of fruits, vegetables, plantation, field and ornamental crops.

Important new Chemicals/Fungicides used in Agriculture

Fungicide group	Mode of Action	Members	Target site	Target pathogen
Strobilurins	Mitochondrial electron transport Inhibitors	Azoxystrobin, Picoxystrobin,	Ubiquinol oxidase (cytochromes b and C1) at the Qo site	All pathogen groups
Phenylamides	Nucleic acid synthesis inhibitors	Metalaxyl Ridomil	RNA polymerase	Oomycetes
Benzimidazoles	Mitosis and cell division inhibitors	Benomyl (benlate) Thiabendazole, (carbendazim), (bavistin) Thiophanate Methyl (topsin M)	B-tubulin assembly (mitosis)	All pathogen except oomycetes

Effective at low doses and possess novel target sites **(Gullino *et al.*, 2000).**

Immunization or Host Plant Resistance

Cross protection

- Protection of plants by mild strain of a virus from infection by most severe strain of the same virus.
- Useful in controlling viral diseases of tomato with mild strains of TMV, citrus with mild strains of citrus tristeza virus and of papaya with mild strains of papaya ring spot virus (PRSV).

Induced resistance (SAR and ISR)

Enhancement of the resistance of a susceptible plant against pathogens in response to an external stimulus without alternation in the host genome is known as induced resistance, and is based on activation of plants own defence mechanism.

Systemic Acquired Resistance (SAR)

- Systemic Acquired Resistance (SAR) is activated after infection by a necrotising pathogen or other biotic / abiotic stresses, rendering distant, uninfected plant parts resistant towards a broad spectrum of pathogens (Kuc, 1982).
- Associated with production of PR proteins and mediated via salicyclic acid.
- e.g. : In tobacco, TMV induces a systemic resistance not only to itself, but also to unrelated viruses, oomycetes (*Phytophthora),* bacteria (*Pseudomonas*) and to certain aphids.

Induced Systemic Resistance (ISR)

- Induced Systemic Resistance (ISR) develop systemically in response to colonization of plant roots by certain PGPR. ISR is transferred by a jasmonate acid (JA) / ethylene sensitive (ET) and nitric oxide (NO) sensitive pathway.
- PGPR able to control plant pathogens by antibiotic effects, site occupancy or competition for iron through Siderophores (Metraux, 2002).
- SAR functions against biotrophic pathogens and ISR against necrotrophic pathogens (Thomma *et al.*, 2001).
- *Fluorescent pseudomonads* produce siderophores such as pseudobactin and pyoverdin which chelate the iron available in the soil and pathogen get died for want of iron. In Rice, seed treatment followed by root dipping and foliar spray with *Pseudomonas fluorescens* showed a higher induction of ISR against sheath blight pathogen (*R. solani*).

Conclusion

Plant Health Management (PHM) can be managed through the traditional techniques *viz.*, Legal, Physical, Cultural, Epidemiological approaches Bio-Control, Chemical and the advanced techniques *viz.*, Host Plant Resistance, Immunization/Improvement of Host Plant Resistance, Development of Transgenic Plants and Biotechnological approaches.

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