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Simulation of Crop-Pest Interactions: Pest Management Applications

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Pest management is a complex system involving many interrelated components such as crop, pests, natural enemies, beneficial organisms and non-target organisms subjected to man's production oriented interventions under a variable weather. The development of an Integrated Pest Management (IPM) strategy requires thorough analysis of the agro ecosystem and thus also known as systems approach or systems analysis to tackle pest problems. Models help to understand and analyze interrelationships among various components of a system. Pest management emphasizes on judicious pesticide application so as to minimize crop loss, conserve environment and ensure favourable economic returns. It also involves intensive decision making requiring effective decision support tool such as economic thresholds and iso-loss curves that are indispensable for judicious pesticide application. Systems approach provides such tools in the form of simulation and decision models. The systems approach is equated to the development, testing and evaluation of a simulation model.

Types of Models

A system is a limited part of real world with inter-related components. The components of a system interact in such a way that a change in any component influences the whole system. In crop protection, four main system types, patho system, cropping system, farming system and agro ecosystem are distinguished. A model is a simplified representation of a system. Basically models can be qualitative or quantitative models. Qualitative models represent a conceptual relationship among different variables of a system without its quantification e.g. indigenous technical knowledge (ITK) of farmers associating weather with pest incidence etc. Quantitative models on the other hand represent a mathematical relationship among various variables of a system. These can be further classified as empirical or descriptive and mechanistic or explanatory models.

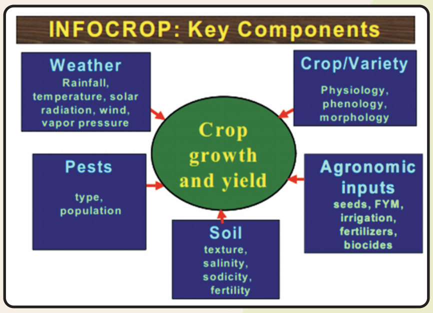
Empirical model: Empirical models represent the damage fundtions among various variables e.g. simple regression between crop yield and pest incidence ($y = a - bx$). These models do not explain the underlying mechanism of yield loss due to pests. Such relationships are liable to spatio-temporal variations thus behave in location-specific manner and cannot be extrapolated without risk of error.

Mechanistic model: Mechanistic models account for the system behavior based on underlying processes e.g. crop growth simulation model. These models are based on quantitative understanding of the underlying crop physiological, meteorological and soil physical, chemical or biological processes and integrate the effect of soil, weather, crop, pests and management factors on growth and yield of crops. The process of developing simulation models and studying systems through them is called simulation. Together with other tools of systems approaches such as expert systems, decision support systems, databases, geographical information system (GIS) and remote sensing, these constitute a valuable tool of information technology that can facilitate integration of knowledge and its utilization by variety of stakeholders. Several mechanistic crop growth simulation models including CERES-Rice; CROPGRO models for grain legumes; MACROS, a generic crop growth model; ORYZA for rice; ALFAPRO2 for alfalfa; SUCROS, a generic model parameterized for wheat, potato, maize; WTGROS for wheat; INFOCROP, a generic crop growth model parameterized for rice, wheat and other crops have been developed.

The integrated pest management did not remain uninfluenced by developments in the area of crop growth simulation modeling. The adoption of simulation modeling in pest management commenced in the late 1960s. Great deal of work on modeling of crop-pest interactions was accomplished by coupling pests' effects to crop growth simulation models at physiological processes level and these coupled models were called crop-pest models. Crop growth simulation models are based on the concept of 'pest damage mechanisms' for simulating crop- pest interactions. InfoCrop, a generic simulation model for annual crops in tropical environments, developed at ICAR-IARI, New Delhi is coupled with pest damage mechanisms and being used for crop protection applications.

Damage mechanisms

Damage mechanisms are the plantphysiological processes affected by thepest injury. Major types of pest damagemechanisms are classified asgermination reduction, stand reduction, light stealing, assimilation ratereduction, assimilate sapping, tissue consumption and tugor reduction. Accordingly the pests can be classified asgermination reducers like mole cricketsand seed maggots; stand reducers such asstem borer, cutworms, termites, dampingoff and wilts; light stealers such as rusts,blights, mildews and sooty mould; assimilation rate reducers like plant diseases; assimilate sappers such as aphids, plant hoppers, whiteflies, mites, thrips, and bugs; tissue consumers like defoliating beetles, grasshoppers, leaf folders, leaf miners, node borers, grain feeders and foliar diseases such as leaf blight, blast and sheath blight and turgor reducers such as nematodes and root pathogens.



The coupling points for damage mechanisms are located at the process level (photosynthesis, respiration, translocation) or at plant organ weight level (leaf area, leaf weight, stem weight, panicle weight). InfoCrop has been validated for important insects, diseases and weeds of rice and wheat crops.

The assessment of crop losses with simulation models i.e. mechanistic approach is a three- step approach taking in to consideration, the pest incidence, pest damage mechanism and the crop yield. Before modeling the effect of a specific pest on crop, it is necessary to quantify the relationship between the pest population/severity and the plant processes affected by it. Some pests affect the crop in several ways e.g. rice brown plant hopper acts as assimilate sapper as well as light stealer and foliar diseases act as light stealer, assimilation rate reducer and tissue consumer as well.

Application of Simulation modelling in Pest Management

Simulation of decision support tools

Crop-pest simulation models can be used to establish location -specific decision support tools, thereby helping to overcome deficiency of the empirical approach. Unlike empirical models, these models can be easily calibrated and validated for local situations and used to determine location-specific economic injury levels (EILs). The model is run from no pest to high pest incidence at short intervals during different crop growth stages so as to assess crop loss and determine EIL. Several pest population scenarios can be evaluated through these models that otherwise is just not possible through empirical approach where there is space and time constraint in conducting field experiments.

Likewise, these models can be used to generate iso-loss curves that may be used for pest monitoring, especially crop diseases and need-based management intervention. Iso-loss curve depict different pest incidence levels at different crop growth stages that result in same yield loss e.g. iso-loss curve for 5, 10 or 20% yield loss. Based on economic value of yield loss, these curves can be used for determining need for management interventions. InfoCrop model has been used to formulate EILs and iso-loss curves for important insect pests and diseases of rice, wheat and other crops.

Agro-ecological pest zoning and Forecasting

Pest zoning is a concept that is particularly applicable for large area pest management and is done using pest-weather model and geographic information system (GIS). Pest population dynamics model is developed based on long term pest and weather data of a representative site in a region. The model is then run with requisite weather data to determine probability of pest outbreak for that site. The site predictions are then extrapolated through (GIS) to carve out the zones of equal pest outbreak potential in entire region. Knowledge of pest epidemic potential in different zones of a region would allow strategic decisions with respect to selection of crop cultivars and appropriate management options.

Simulation models facilitate understanding of factors affecting outbreak and damage caused by pests. The pest population dynamics simulation can be used for pest forecasting and timing of need-based pesticide application. Thermal constant based pest dynamics simulation models have been developed for rice and wheat pests.

Analysis of climate change impact on pests and crops

Global climate change is the most important international issue being discussed extensively at present. It has implications for man's livelihood and his survival. Change in the global climate may affect the crop yields, incidence of pests and economic costs of agricultural production. Extreme weather events have caused severe crop losses and have taken heavy economic toll from farmers across the world. Climate change is expected to have significant. impacts on the distribution, phenology and abundance of many species over the next few decades. The probable effects of climate change on pests may include expansion of their distribution ranges, change in population growth rates, increased period of activity, alteration in crop-pest synchrony and natural enemy-pest interaction, and changes in interaction among pest species.

Traditionally, climate change impact on crop pests has been analyzed through empirical models but these studies being location specific are limited in their application. Process based crop-pest simulation models are thus more suited for this purpose. In general, the crop growth models have been used to analyze impact of climate change on crop growth and yield without considering biotic stresses. Similarly, pest population dynamics models have been used to assess impact of climate change on pests without associating it with crop productivity. Pest dynamics-crop models will be useful tools to assess impact of climate change on pest dynamics and crop productivity both, thereby accounting for its impact on crop-pest interactions as a whole. Linked InfoCrop-pest models have been used for the assessment of likely climate change impact on dynamics of pests of rice and wheat crops and resultant crop losses.

Conclusion

Crop growth simulation models have been used for several applications in the area of pest management, which helped to increase the efficiency of field research greatly. It is important to develop decision support tools based on simulation models to facilitate their application by various stakeholders. These will be of even greater relevance in new emerging research areas such as climate change impacts on pests and crop yield, pest risk analysis for sanitary and phytosanitary requirements and pest forecasting under changing climate.

Chromists as Plant Pathogens

Dr. NP Dohroo
Professor & Head (Retd.)

My interest in Chromista group of plant pathogens started during the year 1977. I seldom realized that it would one day be a different Kingdom with a separate phylum of oomycota and class oomycetes. I found very interesting research to go through the monographs written by Waterhouse on *Pythium* and *Phytophthora*. These are coenocytic fungi and may develop septa at rare occasions during maturity or reproduction. It is very interesting to observe these fungi under a microscope.

In 1981, Thomas Cavalier-Smith established Kingdom Chromista because of their more complex membrane topology and rigid tubular multipartite ciliary hair. Chromista is one of the five eukaryotic kingdoms recognized in the seven kingdom taxonomy. The five kingdom system of Robert H. Whittaker (1959, 1969) has been an important development over the two-kingdom system of plants and animals.

The oomycota is a small division of fungus like filamentous protists commonly known as water molds and mildews especially downy and powdery mildews. The oomycota have been classified as chromists because of their zoospores or sporangiospores possessing heterokont type flagella. The oomycota form a distinct phylogenetic lineage in which the cell wall is composed mainly of cellulose-glucan and devoid of chitin. The vegetative thallus is diploid and meiosis takes place in gametangium rather than in zygote.

Unlike fungi, the oomycetes cell walls are composed of cellulose. Besides, the free living stage of the oomycetes has a diploid chromosome complement. In the oomycete class, the Peronosporales is the thoroughly researched order and include important genera like *Pythium, Phytophthora, Nothophytophthora* and *Phytopythium* as well as the downy mildews *Bremia, Hyalosperonospora, Peronospora, Plasmopara, Pseudoperonospora* and *Sclerospora*. The Pythiales include *Pythium* and *Pilasporangium*. The Albuginales include *Albugo* which causes white blister rust on many valuable plant species. The saprolegniales include *Achlya, Aphanomyces, Saprolegnia* and *Thraustotheca*. The oomycetes are filamentous, microbial eukaryotes that morphologically resemble fungi but belong to the group of Stramenopiles which contain other diverse organisms such as diatoms and brown algae. More than 60% of known oomycete species are plant pathogens.

Economically important diseases caused by *Phytophthora* are late blight of potato, foot rot of black pepper, root rot of apple, bean pod rot and that of *Pythium* are damping off, soft rot of ginger and turmeric. The oomycetes are a class of ubiquitous, filamentous microorganisms that include some of the biggest threats to global food security and natural ecosystems. Some notable examples are late blight of potato, downy mildew of grape vine, sudden oak death, root and stem rot of soybean, stem or foot rot of papaya, blight of colocasia, seedlings blight of castor, leaf and foot rot disease of *Piper betle*, Koleroga or Mahali disease of areca palms, sesamum blight, Albugo rust of crucifers, Sclerospora green ear disease of bajra, downy mildew of jowar and maize, downy mildew of peas, crucifers, cucurbits and grapevines. *Phytophthora sojae* is another highly destructive species that causes huge losses to soybean crop. *P. ramorum* causes the sudden oak death. *Bremia lactucae* and *Plasmopara viticola* are some of the important pathogens of lettuce and grape vine, respectively.

Phytophthora is favoured by moist and cool environments. Sporulation is favored is optimal at 12-18°C. Oomycete pathogens have evolved many mechanisms to subvert plant defences and other cellular processes. These virulence mechanisms include specialized secretion systems for delivering a variety of virulence factors into the host cells. The expression of many of these virulence mechanisms can be affected by environmental conditions. The environmental conditions appear to have pervasive effects on pathogenesis, ranging from pathogen sporulation, pathogen growth and virulence gene expression in plants, and the overwintering of oospores which is critical for initiating infection in subsequent plant-growing seasons. Rainy season and high humidity favour oomycete pathogen sporulation leading to rapid disease development and production of oospores. Disease spread from the soil into the foliage is usually initiated through rain splashes. Once the roots, leaves and fruits in the lower canopy foliage are infected, the pathogen quickly spreads to the upper canopy by rain splashes and other agents. Further, transport of diseased nursery plants, improper disposal of infected material, irrigation with zoospore-contaminated water, changing temperatures contribute to the spread of oomycete diseases.

Chromista group of species can be managed by following integrated disease management practices under immunization prophylaxis system so that oospore activity is prevented. Use of clean seed, neem cake amendments, soil biodisinfestation, biofumigation etc. work well for the management of such diseases. In case if disease appears on foliage plant parts then use of phytosanitary practices, neem based sprays and use of Bordeaux mixture are recommended. Soft fungicides harmless to ecosystem are going to stay as important means of plant disease control in the near future. There has been a significant change in the development of fungicide from simple inorganic compounds to the more present day organic compounds. Many of the important oomycete plant diseases can well be managed by the new compounds which are mostly systemic in nature and are effective at much lower doses.

Research is warranted to explore more sophisticated modern tools to study oomycete genomics. Further there is also lack of genomic data for non-pathogenic oomycete species that play a key ecological role in biological control of plant diseases like *Pythium oligandrum, P. periplocum* and *P. nunn.* Basic research into how temperature, humidity and other abiotic stresses reduce plant immune system would likely impact yield environment-vulnerable points in the plant immune system. Such knowledge may provide a foundation for developing new plant varieties in which the plant immune system is more resilient to environmental fluctuations. In view of the resistance risk associated with most of the systemic site specific compounds, there is a need to develop more classes of soft and safe fungicides with novel target sites.

Role of Microbiome in Plant Immune System

Dr. HR Gautam
Professor and Head

Plants live in association with diverse microorganisms which are collectively called the microbiome. These microbes live either inside (endosphere) or outside (episphere) of plant tissues. Microbes play important roles in the ecology and physiology of plants. They play important roles such as increased nutrient availability, uptake by plants and increased plant stress tolerance. These microorganisms include bacteria as the most common inhabitants, followed by filamentous fungi and yeast strains, protists, and bacteriophages. There can be up to 10^7 microbes per cm^2 present on leaf surfaces of plants, and thus the bacterial population of the phyllosphere on a global scale is estimated to be 10^{26} cells. Researchers studying thale cress plants have discovered that the microbiome, a collection of benign bacteria that live in and on the plant, stimulates a common immune response that helps train the immune system to combat harmful pathogens. These recent findings could have implications for protecting crops against pathogens, which, together with pests, cost the global agricultural industry $540 billion per year. In addition to its implications for plant health, the study also identified an interesting parallel between plant and human immunity. Just after birth, humans start to play host to millions of harmless bacteria that impact the number of white blood cells in the body and also help train the immune system to combat malicious infections throughout life. Plants also host a microbiome, which may have beneficial functions for the plant that are currently not well understood. Only recently, researchers have turned to the microbes on plants to gain insights into their biology.

The researchers conducted an exploratory study with a set of 39 endogenous bacterial strains found on the leaves of *Arabidopsis thaliana*. This species has proved to be an ideal model organism in plant biology because, while it is small and easy to grow, it is closely related to economically important plants, such as turnip, cabbage, broccoli and canola. The researchers found that across all 39 strains, there was a common group of genes that were activated in the plant by the presence of the bacteria, forming a response that the team called the "general non-self response," or GNSR. That means the harmless bacteria living in and on the plant indirectly protect the plant from pathogens by stimulating a protective response, suggesting that, as in humans, these bacteria are training the immune system for later battles with harmful microbes.

Plants employ two layers of defense against pathogens: pattern-triggered immunity (PTI), which is triggered by conserved molecular structures such as microbe/pathogen-associated molecular patterns (MAMPs/PAMPs), and damage-associated molecular patterns, which are recognized by plasma membrane-localized pattern recognition receptors. All plant-associated microorganisms may be pathogenic or nonpathogenic are confronted with the plant immune system. An inspection of a collection of 608 plant-associated bacteria revealed that 97 per cent of them carry at least one potentially immunogenic MAMPs. This raises the question of how nonpathogenic microbes gain access to host plant habitats when confronted with plant immunity. The answer, in part, is the sophisticated ability of the plant immune system to differentiate pathogenic from nonpathogenic microbes using different combinations of molecular cues at fine spatial scales. Furthermore, plants are capable of finely disarming microbial pathogens without perturbing resident microbiota. Both symbiotic and pathogenic fungi such as *Laccaria bicolor* and *Magnaporthe oryzae*, respectively, can suppress host defense response through production of effectors that target the host jasmonic acid signaling pathway. Fungal endophytes promoted induction of phenolic compounds in perennial ryegrass, thereby providing resistance against pathogenic growth. Biosynthetic gene clusters including non-ribosomal peptide synthetase (NRPS) and polyketide synthase (PKS) genes were identified in endophytes, which might contribute to their biocontrol potential. Further, researchers have reported the importance of resident *Pseudomonas* sp. (*Proteobacteria*) in protecting Arabidopsis against infection by a fungal necrotrophic pathogen, *Botrytis cinerea* . Notably, prominent bacterial clades from soil microbiota such as filamentous *Actinobacteria* (*Strepotmycetes* sp.) are able to activate plant biosynthesis of salicylic acid (SA) and promote leaf defense responses against fungal pathogens. Thus, similar to what has been described for pathogens, commensal and beneficial microbes may manipulate plant immune responses through a variety of independently evolved mechanisms, most of which remain to be determined.

Plant host–microbiota interactions are built on the transfer of molecular and genetic information. Plant microbiome can also directly and indirectly extend plant immunity. Indirect stimulation by associated microbiota can occur via induced systemic resistance or induced activation, whereby plant microbiota cause the plant immune system to enter either a sensitive or active state, respectively, both of which can lead to increased resistance to pathogenic microorganisms. Direct interactions between members of the plant microbiome can also have large effects on resistance to pathogens, independently of the plant's intrinsic immune system. Bacterial inhibition of fungal pathogens seems to be a general phenomenon in the plant microbiome and can arise through complex interactions within bacterial consortia. Similarly, antimicrobial production is prevalent among bacterial members of the phyllosphere and likely performs a protective role, too. Finally, the viral component of the plant microbiome may also play a role in plant defense. A recent study has found that treating bacterial wilt disease in tomato by a combination of phages leads to either reduced pathogen density or selection for slow-growing, phage-resistant mutants, both resulting in decreased disease symptoms. These studies raise the exciting possibility that plants may actively enrich particular members of their microbiota or alter their immune vigilance to aid in pathogen defense.

The plant microbiome is a complex web of species interactions governed, to a large extent, by chemical communication between plants and microbes as well as microbe-microbe communication. Almost all hormones have been shown to participate in the plant immune system and thereby help to stop pathogen infections and to balance the interaction with beneficial symbionts. Hormones were found to be instrumental in mediating systemic protection of whole plants in response to local interactions with microbes. Salicylic acid participates in systemic acquired resistance (SAR), a defence strategy where a local pathogen attack at leaves results in plant-wide protection against subsequent pathogen infection attempts. In contrast, jasmonic acid and ethylene function in induced systemic resistance (ISR). ISR is triggered by (beneficial) rhizobacteria, which upon root interaction activate a systemic signalling process to protect the whole plant. Taken together, this designates hormones as part of the plant's tool kit to keep colonisation by pathogenic and beneficial microbes under control. Recent research reveals the role of individual plant immune molecules in fine-tuning microbiome structure. The synthesis of the defense hormones salicylic acid and ethylene alters root microbiota composition in both *Arabidopsis* and tomato plants through the selection of tolerant microorganisms. The vast array of secondary metabolites, called phytoalexins, employed by plants to combat invading microbes seem to also have a broader function of shaping the entire community of plant microbiota. Additional plant-derived metabolites with roles in defense that influence the assembly of the microbiome, promote the attraction or repulsion of specific strains, or both include triterpenes, strigolactones, and benzoxazinoids. Plants exude a multitude of compounds into the rhizosphere that affect microbiome assembly, which in turn influences plant health and development. In conjunction, researchers have begun elucidating microbial chemoreceptors and their role in responding to the chemical cues from their plant host.

Dos and Don'ts While Using Chemicals in Crop Protection

Dr. Kishore Khosla
Professor Plant Pathology (Retd.)

It is extremely important that pesticides be used only when they are needed that is when insect infestation is beyond economic threshold level or the disease pressure is very high. Even under such exigencies one must choose the chemical(s) which is/are safe to our beneficial insects and leave least or no residues in the produce. Many pesticides are toxic to our desirable insect/animals such as honey bees, predators and natural enemies, fish, domestic animals and birds. So take extreme precautions to protect non target or non pest species from direct exposure to pesticides and from contamination due to drift, runoff or residue. It's a common practice on the part of farmers to mix more than one chemical such as fungicide, insecticide and the nutrients to save the time, energy and money in terms of labour. By doing so, in some cases the efficacy of the added chemical(s) gets increased as they have better combined effect. But, if ingredientsdo not have the compatibility the results could be disastrous. Such mixtures have deleterious effect on plants and may spoil the produce. So, one must know the compatibility between the intended chemicals to prepare a mixture solution. If we talk about Bordeaux mixture, dodine and many triazoles, they do not mix well with any other chemical, if mixed, the solution become highly toxic or breaks into flakes and appear as spoiled curd. Therefore, we must avoid mixing of incompatible chemicals and also mixing of emulsifiable concentrate (ECs) to wettable powder formulations or mixing of pesticide with liquid fertilizers. Pesticides are poisonous and must be used with caution.

The foundation for safe use of pesticides is to select the right pest control product and use it according to the recommendations. Also read the label properly before use. One should not use overdose and higher concentration than recommended ones. Using higher concentration than recommended does not yield higher control, rather it adds to the cost and leave harmful traces in fruits and vegetables and pollute the environment and water bodies.Also, excessive applications could cause pesticide runoff and seep into water supplies and contaminate them. Spraying in hot sunny day may cause phytotoxicity and russeting of fruits and in windy conditions spray drift may result into non target coverage and wastage of chemicals. Spraying with copper based fungicides or dodine immediately after rains may cause russeting effect on fruits. Some pesticides are toxic to pollinators also so, avoid their application during flowering. While insecticides have direct knock down impact on honey bees, the application of fungicides such as captan and difenoconazole also hamper their activities. Moreover, the fungicides pollute the pollen grains when applied during flowering and render them toxic. The quality of bee bread prepared from polluted pollen grains is of very poor quality and when fed to the brood by the bees results into mass scale mortality of developing brood.

Due to the lack of complete information on judicious use of pesticides, the farmers are using highly toxic formulations with the intention of getting immediate solution of the problem, has aggravated the situation rather getting relief. Other problems related to it are resistance development in insects and the pathogens, environment pollution, health related issues and persistence of pesticide residues in fruits and vegetables are also of great concern. To fight pests, farmers could no longer rely exclusively on chemicals nor on traditional practices. The mission demands an interdisciplinary approach that combines chemicals and non chemical methods of pest control. To avoid resistance development, use the pesticides carefully, rotate action mechanism and more importantly use in appropriate doses. Therefore, it is of immense importance that the pesticides be used in proper doses, in a balanced manner and with utmost care to maintain their efficacy and keep our environment, food and health clean and poison free.

Lenticel Spots Reported on Immature Fruits of Apple

Dr. Shalini Verma and Dr. HR Gautam

Apple is the most important fruit crop of Himachal Pradesh. However the crop is prone to several diseases and disorders like any other crop. The problem is further compounded by the sudden weather changes. This year the weather from March 2021 onwards had been very erratic.The hot weather conditions during May-June 2021 caused an uncommon disorder called lenticel spot when apple trees were under stress.These lenticel spots developed on immature fruit on the tree. These were more common on the side of the fruit tree exposed directly to the sun and were rarely found on the shady side. These could also have been caused by nutritional imbalance or by a calcium chloride + fungicide spray.The samples with externally visible symptoms were received from several orchards of the state and diagnosed under laboratory conditions. The disorder on immature apple fruits appeared as numerous, small, brown or black spots centered on lenticels, arranged somewhat uniformly on the skin surface. The spots were easily distinguished from normal lenticels being pale brown, dark brown or black.The size of the spots ranged from pinpoint size to upto 1mm diameter. Direct microscopic examination of the spots revealed that these were surrounded by a halo of epidermal cells which had turned brown, appearing as enlarged and rough spot on fruit surface.

Lenticel spots on the apple face exposed to the Sun section through epidermis and lenticel spot on exposed face of apple

Lenticel spots were also examined microscopically for detecting the presence of any associated pathogen. The transverse sections through epidermis and lenticel spot showed brown tissue of the spot consisting of dead cells of epidermis, hypodermis, and outer cortex, containing brown granular matter. A cambium layer was found beneath the dead cells. The phytopathological analysis appeared to establish that such spots were not caused by pathogenic organisms (fungi or bacteria). However, as reported by several workers in developed countries, these spots are sometimes invaded by secondary saprophytic fungi. The routine spray program will help to prevent the secondary fungi from infecting dead lenticels and causing rot during storage.

लहसुन में भण्डारण के नीला फफूंद रोग का खेतों में संक्रमण

डॉ. मीनू गुप्ता, अरूणेश कुमार' और डॉ. शालिनी वर्मा

लहसुन विश्व भर में उगाई जाने वाली कंद फसलों में से एक प्रमुख फसल है। भारत इसके क्षेत्रफल (2.45 लाख हैक्टेयर) तथा उत्पादन में (12.26 लाख टन) चीन के बाद दूसरे सीन पर है। इसमें अन्य कन्द फसलों की अपेक्षा अधिक पौश्टिक तत्त्व होते हैं। इसका प्रयोग सभी प्रकार की व्यंजन बनाने की विधियों में किया जाता है।

इसे बहुत से रोगों के उपचार के लिये भी इस्तेमाल किया जाता है। हिमाचल प्रदेश में भी लहसुन का उत्पादन व्यावसायिक तौर पर किया जाता है। यह फसल प्रदेश के निम्न तथा मध्य वर्गीय किसानों की आय का एक प्रमुख स्रोत है।

प्रदेश की आर्थिकी में नौणी विश्वविद्यालय का भी विशष योगदान है। विश्वविद्यालय के वैज्ञानिक समय समय पर फसल उत्पादन के समय किसानों के खेतों का निरीक्षण करते रहते हैं और संचार के विभिन्न साधनों का प्रयोग करके भी उनकी समस्याओं का समाधान करते हैं। इसी प्रकार मार्च – अप्रैल, 2021 में शिमला तथा सिरमौर जिलों के किसानों द्वारा लहसुन फसल में लगने वाले मुरझान रोग के बारे में बताया। प्रारम्भ में किसानों से मुरझाए हुए लहसुन के पौधों के बारे में जानकारी मंगवाई गई। बाद में अप्रैल में वैज्ञानिकों की टीम ने कुछ क्षेत्रों का दौरा किया। सक्रंमित पौधे छोटे तथा पत्ते मुरझाए हुए पाए गए। इन पोधों को उखाड़ने पर इनके कंद भी आकार में छोटे पाये गये। मरे हुये पौधे छोटे चकत्ते के रुप में खेत में दिखाई दिये। कंदों का पास से निरीक्षण करने पर हरे नीले रंग की फफूंद की वृद्धि दिखाई दी। इस फफूंद का प्रयोगशाला में निरीक्षण करने पर इसे पेनिसिलियम एलाई के रूप में पहचाना गया।

यद्यपि यह फफूंद लहसुन को मुख्यत: भण्डारण में सक्रंमित करके नीला फफूंद रोग उत्पन्न करता है परन्तु अब यह फफूंद खेत में

लहसुन के सक्रंमित पौध

हरे नीले रंग की फफूंद की वृद्धि

भी लहसुन की फसल को सक्रंमित करने लगा है। इस रोग का प्रकोप लगभग 5 – 10 प्रतिशत तक पाया गया।

इस रोग की रोकथाम के लिये भण्डारण के समय लहसुन की रोगग्रस्त कंदों को छाँट कर अलग कर देना चाहिए। इसके अतिरिक्त रोपाई के लिए भी रोग मुक्त व स्वस्थ कलियों का ही रोपण करना चाहिए।

Society Organized a National Symposium- a Report

Himalayan Phytopathological Society (HPS) and Department of Plant Pathology at Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh organized a National Symposium on 'Plant Health Management Beyond 2020' on May 5 and 6, 2021. The event was held in offline and online mode with live streaming on YouTube and Facebook. Eminent scientists from more than 20 reputed institutes of the ICAR and Universities delivered their lectures on smart agriculture technologies during the event. The brief report of the main events in the symposium are as under:

Chief Guest, Dr. PK Chakrabarty, Member, Agricultural Scientist Research Board (ASRB), New Delhi, in his inaugural address said that India is losing about 55-60 million tones of food grains due plant pathogens. He said that marker assisted breeding, map based CHORI r genes, transgenic development, gene editing will usher plant pathology in new era. Simultaneously, he stressed the need for effective use of cultural methods of plant disease management to reduce the use of chemical pesticides. He emphasized the need for proper management of diseases and effective regulations for imported planting material to check the entry of quarantine pests. He specifically cited the examples of wheat blast disease which is a serious disease in neighbouring countries like Bangladesh. He stressed the need for the use of recommended pesticides in crops as per the label claims as the use of more than 85 percent of pesticides is without their registration in specific crops and it can adversely affect the exports of agricultural produce from India.

Dr. Parvinder Kaushal, Hon'ble Vice Chancellor delivering Inaugural Talk

Dr. Parvinder Kaushal, Hon'ble Vice Chancellor being welcomed & presented a memento by DEE, Professor & Head & Organizing Secretary

Dr. Parvinder Kaushal, Vice-Chancellor of Dr Y.S. Parmar University of Horticulture and Forestry lauded the role of the Plant Pathology Department of the University for their contributions to the farming community of Himachal Pradesh and other hilly states to combat serious diseases in fruits, vegetables and ornamental crops especially scab and premature leaf fall in apple. Dr. Kaushal stressed on the need to adopt precision agriculture that makes the use of information technology to achieve precision management with the use of new technologies like nanotechnology, IT and Artificial Intelligence, etc. He was of the view that the production of safe and quality food with an emphasis on eco-friendly methods of disease management was a major challenge in Indian agriculture. He asked the scientists to be vigilant on emerging disease problems in horticultural and forestry crops and provide ready-to-use effective technologies.

Dr. HR Gautam, Professor and Head of Department of Plant Pathology of the host University and President of HPS welcomed the participants. He was of the view that the agriculture sector needs infusion of new technologies which will open new avenues of employment across different fields. He emphasized the need to adopt next-generation technologies to achieve higher productivity of crops using less energy, fertilizer and pesticide while lowering levels of greenhouse gases and coping with climate change. India needs the next green revolution and for that, we have to go for a technology revolution.

Dr. HR Gautam, Professor & Head and Chairman Organizing Committee delivering the Presidential Address

Chief Guest Dr. PK Chakrabarty, Member, ASRB, New Delhi addressing the delegates and dignitaries

There were four Technical Sessions in the Symposium and the first session was chaired by Dr SC Bhardwaj, Principal Scientist and Head of Regional Station of ICAR-Indian Institute of Wheat and Barley Research, Shimla and Dr Kamal Dev Sharma, Professor & Head, Department of Agricultural Biotechnology, CSK Himachal Pradesh Krishi VIshvavidyalaya, Palampur was Co-chairman of the session. Dr Arti Shukla and Dr Meenu Gupta, Senior Scientists of the host institute were the Rapporteurs. Chairman of the session, Dr SC Bhardwaj delivered the first lecture on 'Future Research and Upcoming Technologies for the Management of Wheat Rusts'. In his presentation, he underlined the need to save the useful rust resistance genes for the posterity and need to use the tools and novel principles for the management of wheat rusts. New promising molecular tool CRISPR/Cas9 genome editing is a non-GM technique to have a new resistant and high yielding plant type. In addition, effectors or other chemical bases can also be explored as other tools for rust management. He said that developing new genotypes by precise breeding with the support of rust phenotyping, marker assisted selection and genetic engineering is going to be in the forefront and has to be regular feature for wheat rust management. Co-chairman of the session, Dr Kamal Dev Sharma, in his talk on 'Modern Molecular Techniques to Quell the Menace of Plant Diseases' deliberated about the role of new biotechnological tools. He said that the cloning of plant resistance and avirulence genes owing to advent of biotechnological tools have facilitated better understanding of host pathogen interactions. Elaborating further, he said that new genome editing tools such as CRISPR/Cas system or RNAi coupled with advances in understanding of host pathogen interactions are expected to revolutionize the disease management practices in future.

Dr Manas Kumar Bag, Principal Scientist from ICAR–National Rice Research Institute, Cuttack talked about 'Emerging Technologies for Plant Pathogen Detection with Reference to Rice Diseases'. He informed the audiences that pests and pathogens cause up to 37% of rice yield loss on average. He said that for accurate and precise pathogen detection; advanced and rapid methods such as Polymerase Chain Reaction (PCR), Fluorescence In-Situ Hybridization (FISH), Enzyme Linked Immunosorbent Assay (ELISA), Immunofluorescence, Flow Cyclometry (FCM) and Loop Mediated Isothermal Amplification (LAMP) are some of the direct methods and Thermography, Fluorescence Imaging, Remote sensing Hyperspectral technique are some of the indirect methods which are being currently used.

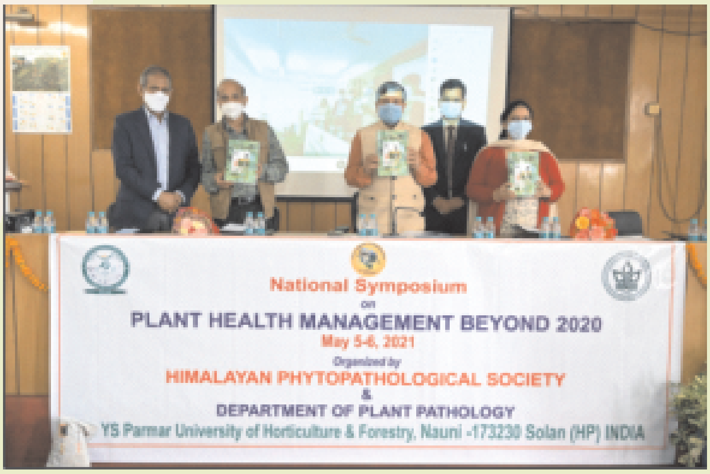
Dr Sanjeev Sharma, Principal Scientist and Head, Division of Plant Protection, ICAR-Central Potato Research Institute, Shimla, in his presentation on 'Futuristic Strategies for Management of Potato Diseases' laid a roadmap of technologies such as prediction models for late blight of potato for effective management of diseases in potato. He further elaborated that with advent of non-transgenic genome editing tools it's now possible to break the barrier of socioeconomic constraints of biotechnology and combat the disease in a comprehensive manner.

Technical session II was chaired by Dr Dinesh Singh, Principal Scientist, Division of Plant Pathology, ICAR- Indian Agricultural Research Institute, New Delhi and co-chaired by Dr Ritu Mawar, Principal Scientist from ICAR- Central Arid Zone Research Institute, Jodhpur, Rajasthan. Dr Dinesh Singh started the session with his presentation on 'Emerging Technologies for Management of Important Bacterial Diseases in Crops'. He highlighted the importance of the bacterial diseases and informed the audiences that about 39 bacterial pathogenic genera are major constraints on crop production and cause significant annual losses worldwide. He pinned his hope on technologies such as induced systemic resistance, antimicrobial peptides, transcription activator like effector proteins are promising areas for the better management of bacterial diseases. Dr Ritu Mawar, from ICAR- Central Arid Zone Research Institute, Jodhpur in her presentation on 'Soil Solarization :An integrated management concept in the context of soil borne plant pathogens' highlighted the potential of soil solarization against soil-borne pathogens especially in the areas with arid climate.

Quarantine has always been an important area of concern due to the influx of imports of the planting material in different crops. Dr. Jameel Akhtar, Principal Scientist, ICAR- National Bureau of Plant Genetic Resources, New Delhi dwelled on this important issue in his talk on 'Strategies to Combat the Threat of Quarantine Pests to the Plant Health and Food Security'. He said that pest-free acquisition of plant genetic resources is one of the goals of plant quarantine and system approaches comprising stringent quarantine regulations, pest and disease survey, robust crop pests diagnostics hold promise to facilitate the movement of plant material in a pest-free state. Dr. PK Shukla, Principal Scientist from, ICAR-Central Institute of Sub-tropical Horticulture, Lucknow outlined the strategies about effective management of diseases of mango and guava in his presentation on 'Advances in the Effective Management of Major Diseases of Mango and Guava'. As protected cultivation is going to be a major component of future agriculture; Dr. DK Banyal, Principal Scientist from CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur dealt with the issue of plant health in protected cultivation in his talk on 'Management of Plant Diseases under Protected Cultivation'. He said that removal of virus infected plants of capsicum and tomato at the beginning is very important in minimizing the further spread of plant viruses. He advocated the use of soil fumigation as eradication strategy under protected cultivation. Further, crop rotation was also advised as strategy to reduce the inoculum of a pathogen usually soil-borne organisms under protected cultivation.

In the Technical session III, Dr S Nakkeeran, Professor, Department of Plant Biotechnology, TNAU, Coimbatore was Chairman and Dr Pawan K Sharma, Principal Scientist from ICAR-National Bureau of Agriculturally Important Microorganisms, Mau, UP was Co-Cairman, The first lecture on 'Our Insight and Future Role of Endophytes in Plant Health Management'.was delivered by Dr Sahana N. Banakar from University of Agricultural Sciences, GKVK, Bengaluru. She said that endophytes may generate phytohormones, fix nitrogen, antagonistic substances, and enzymes, which play an important role in plants responding to stress. Quoting some recent research, she informed that endophytes help their hosts by enhancing plant nutrition by acquiring nutrients from the soil and nitrogen fixation in the leaves. Furthermore, some endophytes may participate in priming plants, which results in a faster and more effective plant defence when pathogens strike. As microbes play a great role in the soil, Dr S Nakkeeran, Professor, Department of Plant Biotechnology, TNAU, Coimbatore, in his presentation on 'Harnessing the Potential of Microbial Consortia to Develop Strategies for Sustainable Plant Health Management' further emphasized on the intricacies of antagonists and pathogen interaction. He said that for developing a consortium, microorganisms that are resistant to environmental shock, diverse mode of action, fast acting, synergistically active, increased hydrolytic enzyme production, easy to handle, having long shelf life, non-pathogenic, economical, ability to trigger both ISR and SAR has to be considered before formulating microbial consortia. Taking the discussion on the topic further, Dr Pawan K Sharma, Principal Scientist from ICAR-National Bureau of Agriculturally Important Microorganisms, Mau, presented holistic view about the usage of microorganisms in his lecture on 'Microbial Resources Centers and Their Role in Meeting Sustainable Goals'. Dr Pankaj Sharma, Principal Scientist from *ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur, Rajasthan in his presentation on 'Trending Technologies for Sclerotinia Rot Management in Oilseed Brassica' said that* integrated disease management practices including cultural, chemical, biological and host innate defense need to be strengthened by their further refinement, retesting and revalidation under variable environmental conditions for the management of Sclerotinia rot in oilseed brassica.

Startups in agriculture are going to play an important role in churning out useful technologies to usher in technology revolution in agriculture. Dr Abhishek Mani Tripathi, Principal Agri-Researcher of Fasal - Wolkus Technology Solutions Pvt. Ltd, Bengaluru explored the possibilities and applicability of ‘IoT- based smart solution in horticulture for crop health monitoring'. He said that in 21st century, modern information and communication (Wireless Sensor Network-WSN) technologies like IoT (Internet of Things) have enabled sensors and data driven approaches to reduce constraints and input costs that limit the ability of the farmers to achieve maximum profitability and improve the production and quality of the horticultural crops. He explained the working of the Fasal System which assists farmers to make decisions by collecting farm level data through IoT enabled sensors. These data are transferred to the cloud and processed with the help of machine learning (ML) approaches mainly Artificial Intelligence (AI) and then the Fasal System forecasts stage wise irrigation time and amount of water required and preventive measures for disease and pest attack.



Dr. Parvinder Kaushal, Hon'ble Vice-Chancellor & other dignitaries releasing the Book in National Symposium

In addition, more the 75 other research papers on varied themes were also presented by the researchers in this National Symposium.

On this occasion, a book entitled 'Technology Strides in Plant Health Management' edited by Dr Narender K Bharat and Dr HR Gautam, was also released which contain 24 chapters on futuristic technologies which certainly help to create thoughts to achieve the intended milestones of higher productivity and profitability in agriculture.

Several awards were also conferred for contributions in the field of plant pathology. The detail of the awardees is as follows:

AWARDS CONFERRED BY THE SOCIETY DURING 2021

Lifetime Achievement Award 2021

The Lifetime Achievement Award 2021 was conferred on Dr. Bir Pal Singh, Former Director ICAR-CPRI, Shimla (HP). Dr. Bir Pal Singh, who retired as Director of ICAR-Central Potato Research Institute, Shimla in 2014 has made commendable research contributions in the field of Plant Pathology. He was born on July 1st, 1953 in a farmer family at Bulandshahar (UP). Dr Singh graduated from AMU, Aligarh and obtained his M.Sc. and Ph.D. Botany degrees from the same university. He joined CPRI, Shimla in 1977 and rose to the position of Joint Director in 2000 and took over as Director of the same institute in 2010 and worked till 2014. Dr Singh is an international authority on potato late blight. He was associated with the discovery of the phenomenon of sexuality in *Phytophthora infestans* in India for the first time; development of more than a dozen potato varieties, late blight forecasting models and decision support systems, eco-friendly management strategies, aeroponic system for potato seed production and field level diagnostic kits. He has published over 200 research articles in national and international journals, handled over a dozen nationally and internationally funded research projects and guided 10 Ph.D. students. He has visited several countries including USA, UK, Germany, Italy, China, Peru, Thailand, Nepal, Bangladesh, Ecuador, Bhutan, Sri Lanka, Mangolia, Indonesia etc. He was on the Board of International Potato center, Lima, Peru; Member-Steering Committee, Global Initiative on Late Blight, CIP, Lima-Peru; Convener, Global Potato Conference-2008; Member-Secretary, Global Conference on Potato-1999; Member, State Horticulture Mission, UP, Member, Management Committee, SVBP University, Meerut; Member, Management Committee, UHF, Solan; Member, Advisory Committee, AIR, New Delhi etc. He is the distinguished Fellow of Indian Potato Association, Shimla; Fellow of Indian Phytopathological Society, New Delhi and NAAS Fellow. He has served Indian Potato Association, Shimla as Business Editor, Secretary, Vice-President and President. He has also been awarded with Hari Om Ashram Trust Award, Late LC Sikka Endowment Award, IPA Kaushalya Sikka Award Memorial Awards, S. Ramanujam Award, ICAR Outstanding Team Research Awards etc.

Young Scientist Award 2021

Young Scientist Award 2021 was conferred on **Dr. Pramod Prasad,** Scientist (Plant Pathology) Regional Station, ICAR-IIWBR, Flowerdale, Shimla. Dr. Prasad was borne on 1st March, 1982 at Village: Dewal, P.O. Bainoli (Nauti), Distt.Chamoli, Uttarakhand. After completing his Ph.D. degree in Plant Pathology from GB Pant UAT, Pantnagar he joined as a Scientist at Regional Station, ICAR-IIWBR, Flowerdale, Shimla during Septembet, 2011. He became Scientist senior scale in 2015 and is working on this post till date in the same institute. His area of research is population biology, host-pathogen interaction and genetics of rust resistance in wheat and barley rusts. He has been associated in identification and designation of wheat leaf rust resistance gene *Lr80*, which is sixth gene reported from India and effective against all races of *Puccinia triticina*; exploring population biology of *Puccinia triticina* from South Asia; decoding the genomes of 15 pathotypes of *Puccinia triticina*; sequencing of the genome of three pathotypes of *Puccinia striiformis* (46S119, 31 & K); deciphering the molecular basis of *Lr24* mediated leaf rust resistance in wheat to *Puccinia triticina* pathotype 77-5; identification and characterisation of ten new pathotypes {46S117, 110S119, 238S119, 110S84, 110S247, 7S0, 6S0, 111S68, 79S4, and 79S68 of *Puccinia striiformis* f. sp. *tritici* and two new pathotypes (107-2 and 20-1) of *Puccinia triticina;* identification of universal susceptible wheat germplasm Local Wheat Hango (**LWH**) and development of rust resistant wheat genetic stock **FLW16, FLW18, FLW31, FLW32 and FLW33** and their registration with Plant Germplasm Registration Committee (PGRC) of ICAR; registered two rust resistant germplasm EC339604 and IC252459 with registration number INGR18012 and INGR18013; discovering novel wheat germplasm resources carrying genes for resistance to all three rusts and spot blotch diseases among 19,460 wheat germplasm collected from within and outside the country. He has 3 projects in hand, He has written 53 research papers, one book, 14 book chapters, 2 manual/technical bulletin, 7 popular articles. He has submitted 9 sequences in NCBI. He is the recipient of 4 Awards.

Dr. RL Munjal Best Ph.D. Thesis Award 2021

Dr RL Munjal Best Ph.D. Thesis Award 2021 was conferred on Dr. Ashish Janraoji Warghane, Assistant Professor, Faculty of Life Sciences, Mandsaur University, Mandsaur (MP). Dr. Warghane was born on 16th April, 1987 in Wardha district of Maharashtra. He obtained his B.Sc. and M.Sc. degrees from RTM, Nagpur in 2009 and 2011, respectively and earned Ph.D. degree from SHUATS, Allahabad (UP) in 2018 with 88.6% marks under the guidance of **Dr. Dilip Kumar Ghosh, Principal Scientist (now Director)**, ICAR – Central Citrus Research Institute Nagpur, Maharashtra, India. His **Ph.D. Thesis** research topic **was** "Molecular detection and characterization of *Citrus tristeza virus* and '*Candidatus* Liberibacter asiaticus' related with citrus decline in India". Regarding the research work he surveyed citrus orchards in states like Assam, Sikkim, West Bengal and Maharashtra and observed citrus decline symptomsand collected disease samples. He maintained the pathogen cultures at ICAR- CCRI, Nagpur and standardized PCR/ RT-PCR protocol used for the detection of *Citrus tristeza virus* and *Candidatus* liberibacter asiaticus for the benefit of different research and academic institutes. He developed PCR/ RT-PCR based protocol used for the implementation of citrus budwood certification program. He also developed Loop mediated based isothermal amplification (LAMP) assay for the rapid, sensitive and robust detection of Citrus tristeza virus, the most devastating pathogen of citrus worldwide which is the first kit devolved in India and second in the world. He has deposited 68 DNA gene sequences in NCBI GenBank for their use in evolutionary and Phylogenetic analysis and development of the diagnostics tools. The data generated under his Ph.D. thesis is very useful for the management of *Citrus tristeza virus* and *Candidatus* liberibacter asiaticus in the citrus growing states. He has published the Ph.D. research work in reputed journal like Journal of Virological Methods (Elsevier) and Indian Phytopathology (Springer Nature) and also contributed a book chapter out of it for a book entitled "Methods in Molecular Biology (Springer Nature)".

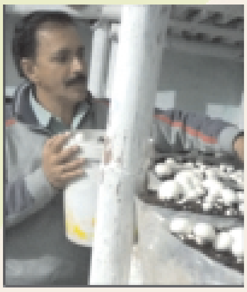
BEST RESEARCH PAPER AWARDS (POSTER SESSION)

Title of Research Paper	Name and Address of Researcher(s)	Position
1. Management of collar rot disease of Chickpea (*Cicer arietinum* L.) caused by *Sclerotium Rolfsii* Sacc. under rice based cropping system	Babariya Vishruta D & Kedar Nath Department of Plant Pathology, NM CoA, Navsari Agricultural University, Navsari (Gujarat).	First
2. Conventional, molecular and doubled haploidy techniques for development of rust resistant wheat varieties for northern hills of India	Madhu Patial, KK Pramanick, Dharam Pal & AK Shukla, ICAR-IARI, Regional Station, Tutikandi, Shimla (HP).	Second
3. Wood rotting fungi associated with tree hosts of District Kangra (H.P.)	Ritu Devi, Sanjeev Kumar Sanyal & Gurpaul Singh Dhingra, Department of Botany, Punjabi University Patiala (Pb).	Third
4. Eco-friendly and cost effective management approaches against Septoria leaf spot of tomato employing biocontrol agents	Vijeta & Sunita Chandel Department of Plant Pathology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP).	Commendation
5. Eco-friendly management of colocasia blight incited by *Phytophthora colocasiae*	Divya Bhandhari, Punjab Agricultural University, Ludhiana (Pb).	Commendation
6. New generation fungicides to combat apple diseases in Himachal Pradesh	Shalini Verma, HR Gautam, Kishore Khosla, Bhupesh Gupta, Usha Sharma & DP Bhandari, Department of Plant Pathology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP).	Commendation

Hon'ble VC, Dr. Parvinder Kaushal Presenting Best Research Paper Award to Dr. Shalini Verma

FARMING HERO

Innovative Farmer Award 2021



The Society coffered **Innovative Farmers Award 2021** on **Sh. Parma Nand**, Village Chammo, PO Gaighat, The Kasauli, Dist Solan (HP) who is a successful mushroom entrepreneur. Sh. Parma Nand, after attending a training programme at KVK, Solan in 2018-19, started mushroom cultivation at his farm. During 2020, he prepared around 40 tons of compost and harvested around 9 tons of mushroom with a net profit of Rs. 2.5 lakhs even during Covid-19 period. During Covid lockdown, the rates of mushrooms in Sabzi Mandi were only Rs. 30-50 per kg but then he conceived an innovative idea of selling his produce in the nearby villages as during lockdown period the nearby villages didn't have much access to such perishable commodities. He got better price (Rs. 70-80 per kg) for his produce and earned a net profit of Rs. 2.5 lakhs. He even used B and C grade mushrooms to prepare pickle and also sold that. He is regularly cultivating button and oyster mushrooms and till date, has earned a net profit of Rs. 10-12 lakhs from this venture in last two years. His future plan is to start cultivation of milky and Shiitake mushrooms. He has become a source of inspiration to rural youth of surrounding area. Many farmers have visited his farm and are inspired to start mushroom cultivation under his technical guidance. Now he is also preparing and selling compost to other farmers thereby, getting additional income. For oyster mushrooms,he was not getting good price in Dhrampur or Solan market. Then, he contacted big hotels in surrounding area where he placed few bags of Oyster mushrooms it the premises of the hotel itself, which became a source of attraction to the tourists also and they started demanding oyster mushroom dishes. With this innovation, he sells his produce at premium price of Rs. 300 per kg. **His success story got published in ICAR handbook on "Innovative Agri Solutions during Covid 19" at page Nos. 38-39.** He has also received **Progressive Farmer Award** during 36th Foundation Day of Dr YS Parmar University of Horticulture and Forestry, Nauni on 1.12.2020.

NEWS DESK

Field Laboratory Inaugurated

Hon'ble Vice Chancellor, Dr. Parvinder Kaushal inaugurated the newly constructed Field Laboratory of the Department of Plant Pathology on 22nd March, 2021