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Technical Session I

Host plant resistance

Unraveling the identity of the fungal cell wall components that holds the key for antifungal function of plant defense protein- Cocculus trypsin inhibitor

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Plants are continuously exposed to insect pest and pathogen invasion during their life cycle. Protease inhibitors (PIs), class of pathogenesis-related (PR) proteins, usually present in seeds, tubers, leaves. They act by attenuating enzyme function necessary for metabolic processes such as protein turnover or nutrient assimilation. Vast majority of Serine Protease (SPs) are digestive proteases involved in metabolic food processing, host tissue penetration, reproduction, evasion of the host immune system and developmental processes. SPIs from plant origin have been reported to have inhibitory effect against fungal pathogens. We have reported *Cocculus hirsutus* Trypsin Inhibitor (ChTI) of 18kDa from *Cocculus hirsutus*, a climber of the family Menispermaceae, with temperature stability up to 70°C with a narrow pH range 7.0-9.0 and is effective against most of the biotic stress experienced by the plants. We took up investigation to understand as to how this protein acts against fungal pathogens. We used *S. cerevisiae* and its cell wall mutants as a model system to study the mode of antifungal activity exhibited by ChTI. Among the yeast mutants, Mnn1, which lacks 1, 3 mannosyl transferase, was highly susceptible to ChTI. 1,3 mannosyl transferase adds mannan layer during final stages of cell wall synthesis /maturation of fungal mycelia. Further studies revealed that ChTI binds to phosphodiester linkage of the phosphomannans which are integral part of the fungal cell walls. Fluorescent microscopy analysis reveal that FITC labeled ChTI binds to Mnn1 and the actively dividing yeast cells as well as growing conidial tip of the fungal mycelia. Thus, we opine that ChTI like proteins bind to the phosphodiester linkage in the middle layer of the cell wall and inhibits the further maturation of the conidial, hinders the growth of the fungal mycelia.

Single consortium-primed establishment of resistance in ragi against *Magnaporthe grisea* (Hebert) Barr

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Ragi, a high nutrient millet, is susceptible to more than twenty pathogens of which blast disease caused by *Magnaporthe grisea* (Hebert) Barr. is most severe, resulting in an annual loss of 50%. *M. grisea* is highly virulent due to its wide host specificity (rice, wheat, rye, barley and pearl millet). Many strategies have been used to manage blast disease, of which use of beneficial soil microbes in induced systemic resistance (ISR) is the recent. In the present study, the isolates of *Bacillus* (JUB1-JUB10) and *Pseudomonas* (JUP1-JUP10) sp. from different rhizospheres collected randomly were screened for growth promoting traits, of which isolates JUB9 and JUP10 were shortlisted for further studies. Studies on the production of mycolytic enzymes showed that the shortlisted isolates were positive for protease, chitinase, cellulase and amylase with highest protease production of 409.36±17.84 (JUB9) and 390.64±18.74 (JUP10). Greenhouse studies on seed-priming with the isolates JUB9, JUP10 and their combination showed elicited resistance against pathogen when compared to the challenged control (CC) and untreated control (UTC). Time course studies on accumulation of α -1,3-glucanase, chitinase and phenylalanine ammonia lyase (PAL) upon challenge inoculation in primed and control plants were carried out at 24, 48, 72 and 96 hpi. Enhanced enzyme activity by the combination primed plants at initial time course showed connexion with greenhouse studies which boosted the induction of resistance against blast disease. Lignin, the cell barrier, upon challenge inoculation in leaf samples was quantified. The phenylpropanoid pathway product was biochemically estimated at 72 hpi which showed profound increase in consortium primed plants paralleled to CC and UTC. This indicates that the consortium initiates the signals for secondary metabolite production thereby induce the cell barrier and hence increase its resistance against the intruder. This strategy imposes the use of sustainable inducers against pathogens for ringing about resistance in plants.

Evaluation of turmeric varieties against leaf spot disease caused by *Colletotrichum capsici*

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Turmeric (*Curcuma longa* L.) is one of the important spice crops grown in most part of the Karnataka and India. The leaf spot disease caused by *Colletotrichum capsici* is one of the limiting factors for the cultivation of turmeric causing considerable yield losses in majority of turmeric growing areas in Karnataka and India. Eight turmeric varieties viz., Alleppy, Chaitanya, Cuddapa, IISR Prabha, IISR Pratibha, Rajapuri, Salem and Suguna were evaluated for their resistance against the leaf spot disease under natural disease pressure conditions. Among them, the varieties Salem and IISR Pratibha were found to be moderately resistant with disease severity of 20.83 and 24.58 per cent respectively. Whereas, the variety Cuddapah was susceptible registering maximum disease severity of 78.33 per cent. The variety Salem also recorded maximum fresh rhizome yield (40.01 t/ha) followed by the variety IISR Pratibha (35.06 t/ha) whereas, the least fresh rhizome yield was noticed in the variety Cuddapa (28.05 t/ha). Thus the varieties Salem and IISR Pratibha were found to be moderately resistant to the disease.

Confirming the resistant sources of heat tolerant maize (*Zea mays* L.) inbred lines for turcicum leaf blight (*Excerohilum turcicum*) and aflatoxin contamination (*Aspergillus flavus*)

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Among biotic stresses affecting maize, the preharvest aflatoxin contamination produced by *Aspergillus flavus* and turcicum leaf blight (TLB) caused by *Excerohilum turcicum* are most important diseases in India. Resistance of maize to aflatoxin contamination and TLB, is a alternate goal in breeding programs that screen for these important traits with the aim of developing resistant commercial hybrids. Hence, a study on reaction of 26 inbred lines of heat tolerant maize to both the diseases was conducted under artificial epiphytotic field conditions for two seasons. Among 26 inbred lines evaluated for TLB, 10 lines namely CAH-1533, CAH-1505, CAH-158, CAH-1437, H-15002, E-5, CAH-1526, CAH-1454, CAH-1532 and CAH-1545 showed resistant reaction. Whereas, five lines were found moderately resistant viz., CAH-1551, CAH-1504, CAH-1564, CAH-1536 and CAH-1501 and remaining were severely affected by TLB and rated them as susceptible. Study on reaction of 28 inbred lines for aflatoxin contamination revealed that, among them none were immune, whereas, nine lines namely CAH-1546, CAH-1525, H-15001, ARLUM, CAH-1437, CAH-1503, CAH-1526, CAH-1545 and CI-4 were highly resistant to aflatoxin contamination. The resistant reaction was exhibited by 17 lines, while two inbred lines namely CAH-1551 and CAH-1501 showed moderately resistant to aflatoxin contamination. Thus, the above lines were identified as promising sources of resistance and can be used successfully in developing desirable level of resistance in disease endemic areas to aim for sustainable productivity.

Screening of black pepper (*Piper nigrum*) genotypes against the foot rot disease caused by *Phytophthora capsici*

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Black pepper (*Piper nigrum* L.) is a perennial vine which originated from the Western Ghats of India and is called as 'King of Spices'. This perennial vine suffers from several diseases in different stages of its growth in nursery, immature and mature plantations. Among them, foot rot or quick wilt caused by *Phytophthora capsici* (Berk & Curt.) Wei. is a major threat for black pepper cultivation. Attempts were made to find out the disease resistance source by screening the black pepper genotypes against the foot rot disease. Thirty nine genotypes were tested for foot rot disease resistance under natural infection in areca nut based cropping system. It was found that all the genotypes tested were infected with disease and showed differential reactions for the foot rot infection. The Genotypes Ademane (7%), Acc-53 (9%) BPS-4 (8%), HP-812 (9%), BPS-1 (8.5%), P 24 (9.5%), HP-34(8%), BPS-2 (9.5%), PRS-21 (8%), PRS-22 (9%), Malligesara (9.5%), C-1090(9%) HP-813 (8%) and BPS-3 (9.5%) showed < 10 per cent disease intensity and showed some tolerance to foot rot disease. Four genotypes viz., Karimalligesara, OP Karimunda-1, P-4, Kudargutta, PRS-64 recorded moderate disease intensity ranged from 10 to 20 per cent. Remaining 29 genotypes were recorded >20 per cent disease intensity and showed higher susceptibility to foot rot disease. The information generated may be very useful especially due to the narrow genetic base of cultivated pepper and can be exploited further by systematic breeding programmes for foot rot disease.

Evaluation of different pigeonpea varieties for resistance against pigeonpea wilt complex

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Pigeonpea is an important crop being cultivated in semi arid tropics particularly in Indian subcontinents, Southern and Eastern Africa. Locally available 12 pigeonpea cultivars were obtained from agriculture research station, Kalaburgi and screened for resistance to wilt complex caused by fungi *Fusarium udum* in association with pigeonpea cyst nematode *Heterodera cajani*. The seeds of all 12 cultivar were sown in earthen pots containing sterilized soil and sand (1:1) mixture. The experiment was conducted under glasshouse conditions and 15 days old seedlings were inoculated with *F. udum*, *H. cajani* and *F. udum* + *H. cajani* along with uninoculated control. The results revealed that, out of 12 cultivars, eight cultivars viz., Asha, Bennur local, BSMR-736, Chaple, GRG-811, Maruti, Pink variety and WRP-1 were shown moderately resistant reaction. Three varieties viz. Gulyal local, Katti beeja and TS-3R were shown moderately resistant reaction and one variety i.e., GS-1 was shown highly susceptible reaction against *H. cajani*. In case of *F. udum* alone treatment, six pigeonpea cultivars (Bennur local, Chaple, GS-1, Gulyal local, Katti beeja and Pink variety) showed susceptible reaction, three varieties (Asha, BSMR-736 and Maruti) showed moderately resistant reaction and GRG-811, TS-3R and WRP-1 varieties showed resistant reaction. When these pigeonpea varieties screened against *F. udum* + *H. cajani* all the varieties found susceptible.

Mechanisms of resistance to begomoviruses in vegetable crops

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Geminiviruses comprise a large and diverse family of viruses that infect a wide range of important monocotyledonous and dicotyledonous crop species and cause significant yield losses. The family Geminiviridae is divided into three genera, one of which is Begomovirus. Currently, over 100 begomoviruses are known to be transmitted by at least two biotypes of *Bemisia tabaci* to more than 20 different cultivated species of socioeconomic importance. Some of the main crops affected by whitefly-transmitted geminiviruses are common bean, lima bean, cowpea, tomato, potato, eggplant, chilli, peppers, melons, squash, okra and cassava. The existence of *B. tabaci* biotypes and numerous whitefly-transmitted geminiviruses affecting food and industrial crops has become a major constraint to agricultural development in tropical and subtropical regions of the world. Chemical control methods have been only partially effective, since whitefly populations can reach very high numbers, leading to intensive pesticide use to eliminate the vector before it transmits the virus. Furthermore, there are concerns that the vector may develop pesticide resistance and the intense application of pesticides may have deleterious effects on the environment also. To manage them properly, we should have better understanding of resistance mechanisms responsible for imparting resistance to different begomoviruses. These defence mechanisms are principally based on immune, resistance and tolerance. Resistance can be obtained by naturally (R-gene mediated, antixenosis and antibiosis) or artificially (pathogen-derived resistance, post-translational gene silencing, etc) in plant system. The basis of plant resistance against virus can be classified as Morphological (Wax, cuticle thickness, hair shape etc), Physiological (activity of stomata), Biochemical (Defence chemicals: Phytoalexins, phenolics) and Genetical (Ty gene for ToLCV resistance in tomato). *Solanum hirsutum* and *S. peruvianum* were resistant to Tomato leaf curl virus (ToLCV) due to the production of exudates from trichome glands on the leaf surface, in which white flies get entrapped in tomato. Using RNAi method, dual begomovirus and *B. tabaci* resistance has been developed.

Studies on the role of phenols and flavonoids in resistance against *Fusarium* wilt in carnation (*dianthus caryophyllus* L.)

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An investigation was conducted on “Studies on the role of phenols and flavonoids in resistance against *fusarium* wilt in carnation” at the Division of Floriculture and Medicinal Crops, Indian Institute of Horticultural Sciences, Hessarghatta, Bengaluru. Twenty carnation genotypes were screened for resistance against *fusarium* wilt caused by *Fusarium oxysporum* f. sp. *dianthi* (*Fod*). The changes in phenol and flavonoid contents among the *Fod* inoculated and uninoculated carnation plants was assessed and it was observed that the inoculated plants recorded higher contents of phenols and flavonoids than the uninoculated plants. Among the twenty genotype, Gioele which was resistant to *fusarium* wilt recorded the highest phenol (151.84 mg GAE/100 g) and flavonoid content (49.55 mg CE/100 g), whereas the highly susceptible genotype Dark Dona recorded the lowest phenol (38.25 mg GAE/100 g) and flavonoid content (21.81 CE/100 g). A detailed analysis revealed that the resistant genotypes recorded higher phenol and flavonoid contents both before and after *fusarium* wilt incidence. The resistant carnation genotype Gioele recorded an increase in phenol content by 18.71 % and in flavonoids by 24.04 %, when compared between inoculated and uninoculated plants. On the contrary, the susceptible genotype recorded a mere increase of 9.17 % in phenol content and 13.85 % in flavonoid content. The outcome of the investigation could possibly be used in biochemical characterization of carnation genotypes for further breeding programs aimed at resistance against *fusarium* wilt.

Investigating the role of plant defence enzymes in resistance against *Fusarium* wilt in carnation (*Dianthus caryophyllus* L.)

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A study was conducted at the Division of Floriculture and Medicinal Crops, Indian Institute of Horticultural Sciences, Hessarghatta, Bengaluru to assess the role of plant defence enzymes viz., peroxidase and phenylalanine ammonia-lyase in resistance against *Fusarium* wilt caused by *Fusarium oxysporum* f. sp. *dianthi* (Fod) in carnation genotypes. A total of 20 carnation genotypes were initially screened for resistance against *Fusarium oxysporum* f. sp. *dianthi*, followed by they were analyzed for their peroxidase and phenylalanine ammonia-lyase activity under both uninoculated and inoculated conditions. Among the 20 genotypes, the resistant genotype Gioele recorded the highest activity for both peroxidase and phenylalanine ammonia-lyase activity under uninoculated (0.805 Å abs/min/g FW and 0.205 µg cinnamic acid/g/min respectively) and inoculated (1.268 Å abs/min/g FW and 0.305 µg cinnamic acid/g/min respectively) conditions. Contradictorily, the susceptible genotype Dark Dona recorded the least peroxidase and phenylalanine ammonia-lyase activity under uninoculated (0.186 Å abs/min/g FW and 0.090 µg cinnamic acid/g/min respectively) and inoculated (0.125 Å abs/min/g FW and 0.130 µg cinnamic acid/g/min respectively) conditions. The resistant genotype Gioele recorded the highest peroxidase and phenylalanine ammonia-lyase activity (57.51 and 48.78 % respectively) compared to the susceptible genotype Dark Dona (15.59 and 44.44 % respectively). The study clearly describes the role of peroxidase and phenylalanine ammonia-lyase enzymes in resistance mechanism against *Fusarium oxysporum* f. sp. *dianthi*, which can be used as a tool to identify resistant carnation genotypes.

Effect of systemic acquired resistance and induced systemic resistance inducing agents against *Exserohilum turcicum* under *in vitro* and *in vivo*

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Maize crop is being affected by many diseases, among those turcicum leaf blight (TLB) is an important destructive disease caused by *Exserohilum turcicum*. Disease management by inducing resistance in plants using SAR chemicals and ISR bioagents is an important approach. SAR chemicals were used to induce resistance in host plants, which defends against the pathogenic infection. This systemic acquired resistance spreads to untreated part also. Resistance inducing chemicals were screened under *in vitro* against the mycelial growth of the pathogen. The results showed that, salicylic acid at 5 mM, 10 mM and 20 mM concentrations were effective in inhibiting the mean mycelial growth of 97.77 per cent. Least mean inhibition of mycelial growth of *E. turcicum* was observed in potassium nitrate (58.32%). The effect of resistance inducing chemicals was further studied under *in vivo* indicated that, the maximum germination per cent, shoot and root length and high vigour index was observed in both resistant and susceptible inbred lines treated with mannitol at 10 mM concentration. But least germination per cent, shoot length, root length and vigour index was observed in both inbred lines treated with sucrose at 10 mM concentration. Among the five bioagents (ISR agents) *Trichoderma viride* (Tri-25) was highly effective in inhibiting the mycelial growth (66.29%). Least inhibition was observed in *Pseudomonas fluorescens* (EP-5) (31.48%). This could be obviously due to several possibilities of existence of microbial interactions such as stimulation, inhibition, mutual intermingling, over growth of antagonistic isolate over test pathogen and inhibition at a distance etc., The effect of resistance inducing bioagents were further studied under *in vivo*, the maximum germination, shoot and root length and high vigour index was observed in *T. viride* (Tri-25). Higher vigour index was observed in *T. viride* (Tri-25) in both resistance and susceptible lines, which was due to their support for developing good root growth.

Identification of the stable resistance for stable resistance against *Macrophomina* blight/ stem canker (*Macrophomina phaseolina* (Tassi) Goidanich) in pigeonpea (*Cajanus cajan* (L) Millsp)

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The yield potential of high yielding variety can only be obtained, if plant stand at initial crop growing stage is well established. There are several soil borne diseases, affecting the seedling at vary initial crop stage. *Macrophomina* is one of the important soil born disease of pigeonpea crop especially in southern part of India, affecting the crop and reducing the plant stand in the field. It was observed that in severally affected field, 60-70 % of the plants are vulnerable to this disease, causing severe damage. In order to assess the resistance of medium duration pigeonpea, twenty two genotypes were screened in the kharif season at two locations (Coimbatore - Tamil Nadu and Varanasi - Uttar Pradesh) for consecutive two year (2012-13 and 2013-14) in field condition. The mean incidence ranged from 25.50% at Varanasi to 47.35% at Coimbatore. The genotypic variation is high ranging from 20.85% in MA 6 to 54.4% in BRG 3 near its locations and years. MA 6 and IPA 204 have least mean score of 20.85 and 21.40 respectively. Among them MA 6 also has least deviation from regression (9.08) $bi(1.18) \sim 1.00$. IPA 204 although having $bi \sim 1.00$, deviation and over location and year is of high magnitude. There are four other genotype possessing the stable resistance showing $< 30.0\%$ incidence, $bi \sim 1.00$ and low deviation from regression are WRP 1 (23.8), RVSA 07-29 (26.30), KPL 44 (27.635) and BRG 11-1 (28.45%). These genotypes can be effectively utilized in breeding program for incorporating the stable moderate resistance in high yielding but susceptible to *Macrophomina* blight pigeonpea cultivars to withstand the incidence of this dreaded disease.

Diversity of resistance in wheat genotypes against natural infection of *Fusarium* Head Scab (FHS) at Wellington

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Wheat is major cereal crop cultivated for domestic consumption and export in India. Rusts (particularly yellow rust) are major threat to reduce yield and quality of wheat grains and therefore, large numbers of genetic stocks and commercial varieties have been developed through well organized national level net work and collaborative research. However, much attention was not given for other fungal disease like head scab or blight. *Fusarium* head blight (FHB) or head scab (HS) incited by *Fusarium graminearum* Schwabe [teleomorph: *Gibberella zeae* (Schwein.) Petch], is becoming a devastating disease in wheat especially on *Triticum aestivum* spikes. This particular disease drastically reduces grain yield (less weight) and quality (alteration in nutritional status) in addition to production of mycotoxins. The mycotoxins [deoxynivalenol (DON) and nivalenol (NIV)] elaborated by pathogen are harmful to humans and animals. Management of such polygenic and necrotrophic pathogen is challenging under variable environmental conditions. The IARI, Regional station, Wellington plays vital role in evaluation and identification of resistant types from large number of genetic stocks during off-season summer and pathological nurseries. Hence, by utilizing these facilities, in present investigations, a total of 151 wheat varieties developed under different agro-climatic zones (NHZ-northern hill zone, NWPZ-north western plain zone, NEPZ-north eastern plain zone, CZ-Central zone, PZ-Peninsular zone, SHZ-Southern hill zone) in addition to different special trials were planted for field evaluations. All agronomical practices were followed till maturity, evaluation and harvest of these genotypes. Test genotypes were regularly

monitored for incidence of the disease. The percentage of infected spikes and severity were recorded regularly. The pooled data were analyzed to categorize proportion of infection among groups of genotypes. The following genotypes were completely free from head scab (HS 542 (C), DBW 88 (C), DBW 90 (C), HD 3086 (C), PBW 644 (C), WH 1021 (C), WH 1080 (C), WH 1124 (C), WH 1142 (C), DBW 39 (C), HD 2733 (C), HD 2888 (C), HD 3171 (I), K 1006 (C), K 1317 (I) (C), HI 8627 (d) (C), MP 3288 (C), MACS 4028 (d), UAS 375, GW 322 (C), DBW 14 (C), DBW 71 (C), DDK 1029 (C), HW 1098 (C), KRL 210 (C), HPW 439, HPW 448, HS 645, UP 2993, VL 1013, VL 4002, VL 4003, BRW 3773, DBW 196, HD 3226, HD 3237, HI 1617, HI 1619, HI 1620, HP 1963, MP 1318, DBW 187, HD 3219, UAS 387, DBW 248, DDK 1052, KRL 370, KRL 386, MACS 5047, MACS 5049, 1316, TL 3011, TL 3014, TL 3015, DBW 249, DBW 251, PBW 757 and PBW 778). Wheat varieties from very high altitude registered cent per cent infection in all varieties with an intensity ranging from 10 to 50 %. Few varieties (VHA-01, VHA-05, VHA-07 and VHA-10) recorded a maximum of 50% infection. Fifty percentages of varieties from NWPZ were free from head scab than high incidence from rest of the zones. Maximum 25% intensity was recorded in DBW 189, PBW 750 and PBW 752. The resistant types indentified in present studies could be useful as source of resistance after re-evaluation in summer season so that true resistance could be realized under the influence of variable weather conditions and pathogenic population of *F. graminearum* at Wellington.

Genetics of inheritance to Watermelon Bud Necrosis Virus (WBNV) resistance in watermelon [*Citrullus lanatus* (Thunb.) Matsum & Nakai]

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Watermelon is a major cucurbit and an important vegetable crop of India. In India it is cultivated in an area of 81890 hectares with the production of 2038.24 thousand metric tonnes. Our productivity levels are constrained by the occurrence of various diseases. Important among them, is a thrips transmitted Watermelon Bud Necrosis disease caused by a Tospo virus. Severe yield losses throughout India have been reported because of this disease. The incidence ranges between 39-100% with yield loss of 60-100%. Watermelon bud necrosis virus (WBNV) is prevalent in watermelon growing areas particularly in the states of Karnataka, Andhra Pradesh and Maharashtra. This study was conducted to understand the genetics of inheritance to WBNV resistance in populations (P₁, P₂, F₁, BC1 & BC2) of the cross involving resistant (IHR-19) and susceptible (IHR-140) parents. These populations were screened for disease reaction under natural epiphytotic conditions during summer 2017 in a randomized complete block design with replicated thrice. Performance of six generations based on mean per cent disease incidence (PDI) revealed P₁, F₁, F₂ and BC1 to be resistant while, BC2 and P₂ were susceptible. The data was subjected to generation mean analysis and the results revealed the significance of scaling test indicating inadequacy of simple additive-dominance model and the presence of epistasis. All components except additive x dominance were found to be significant, among them only additive and dominance x dominance effects were negative and contributing towards resistance. The trait recorded a low heritability with estimated broadsense heritability of 25.3 per cent and narrow sense heritability of 12.1 per cent. Opposite signs of h and l revealed duplicate type of epistasis. As the dominance x dominance component is in higher magnitude, heterosis breeding can be employed for incorporating resistance.

Identification of transgressive segregants for ToLCV disease resistance in F₂ segregating population

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Tomato leaf curl virus (ToLCV) is one of the major disease in tomato known to be transmitted by the vector whitefly (*Bemisia tabaci* Genn.) and result in losses are over 90 per cent. Resistant breeding is an integral part of the crop improvement programme and hence, exploration of host plant resistance is safe, durable and economic approach to manage the disease. With this background F₂ progenies of IIHR-2201 X C-13-1-2-1 and D-12-1-6-1 X D-6-1-6-1 were screened for ToLCV disease resistance to identify the source of resistance against the tomato leaf curl virus. In IIHR-2201 X C-13-1-2-1 F₂'s, out of 305 F₂ families evaluated, 217 showed resistant phenotype, 88 families were susceptible for tomato leaf curl disease incidence. Similarly, out of 305 F₂ families in D-12-1-6-1 X D-6-1-6-1 F₂'s, 214 were classified as resistant, 91 as susceptible families to tomato leaf curl disease incidence under field condition. The inheritance ratio 3 (resistant): 1(susceptible) indicated the involvement of single dominant gene in governing the resistance to tomato leaf curl disease. Seventeen superior plants *i. e.*, plant number 18, 29, 33, 35, 43, 64, 81, 88, 89, 133, 134, 144, 158, 224, 248, 253 and 261 from the cross IIHR-2201 X C-13-1-2-1 were identified as superior for ToLCV resistance as well as for good yield attributing characters. The transgressive segregants were not selected in the cross D-12-1-6-1 X D-6-1-6-1 due to unacceptable fruit quality. Attempts to manage this disease with different methods have so far proved ineffective and the use of resistant cultivars remains the best control strategy.

Identification and characterization of NBS-LRR resistant gene analogues from rose against powdery mildew

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Powdery mildew is the most important disease of rose especially when grown in polyhouses and field. Severe infection of powdery mildew reduces the economic value of roses and subsequent loss of planting material. Most desirable method for powdery mildew management is the development of resistant varieties. Identification of resistant gene (R genes) from plant species is an important strategy for breeding programs. R genes play vital role in plant defense mechanism against pathogen and NBS-LRR (Nucleotide Binding Site - Leucine Rich Repeats) is the major class of R gene family in plant species. The present study reports the identification and molecular characterization of resistant gene analogues from IIHR variety of rose. The powdery mildew resistant line at IIHR (IIHR 13-4) was selected based on earlier reports. PCR based approach with degenerative primers based on different conserved motifs of NBS- LRR was used for isolating resistant gene analogues (RGAs) from rose. Seven rose RGAs were selected (IIHRR13-4R1, IIHRR13-4R2, IIHRR13-4R3, IIHRR13-4R4, IIHRR13-4R5, IIHRR13-4R6, and IIHRR13-4R7) based on sequence analysis and similarity search. The selected RGAs were showed similarity to RGAs of other plant species. R genes isolated from rose in the present study belong to TIR -NBS-LRR (Toll interleukin Receptor- Nucleotide Binding Site - Leucine Rich Repeats). Different motifs of seven RGAs identified are P-loop, kinase 2, kinase 3a and GLPL of NBS domain. Rose TIR - RGAs identified carry an aspartic acid residue (D) at the end of kinase 2 region (NBS III).The results of present study will help to develop RGA based markers linked to powdery mildew resistance in rose and this will help for rose resistant breeding.

Development of screening protocol for Tospo (tomato spotted wilt) virus in tomato

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Tospo virus is one of devastating plant virus which causes heavy losses in tomato it is transmitted by thrips, vector management has very less success to reduce the disease, hence host plant resistance is best, therefore the resistance genes are found in wild tomato (*Solanum peruvianum* L.) has to be transferred into cultivated tomato spp. Hence a rapid screening protocol is necessary for screening the segregating population. For screening the lines first, the infected tomato leaves were collected from the field these leaves were cleaned and crushed in pestle and mortar with phosphate buffer then sap inoculation was done on 7 days old cowpea plants (at 4 leaves stage) after 3-4 days of inoculation, the cowpea plants expressed local as well as systemic symptoms of Tospo virus, after that infected samples from cowpea plants showing systemic symptoms were collected. Then again, these samples were crushed and sap inoculated to 20 days old *Nicotiana benthamiana* Domin plants then these plants were showed symptom of Tospo virus within 4 days of inoculation, then after this finally the disease samples were collected from *Nicotiana benthamiana* were inoculated to susceptible tomato plants, symptoms of Tospo virus were observed within a week, from this technique we could able to get about 90-95 per cent of the Tospo virus symptoms for further for getting 100 per cent disease we should again have to improve the protocol if this method helped to get 100 per cent disease, by this technique we can rapidly screen the tomato lines against Tospo virus in green house conditions.

Screening of the maize inbred lines and hybrids for identifying source of resistance and resistant genotypes against post flowering stalk rot of maize

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Maize is the third most important cereal crop in India after rice and wheat. Diseases are one of the major constraints in realizing the potential yield. In India about 13.2 per cent yield losses have been estimated due to diseases annually. Post flowering stalk rot complex is one of the most serious, destructive and widespread groups of diseases in maize. Host plant resistance is considered as most practical, feasible and economical method of plant disease management. The resistant varieties conserve natural resources and reduce the cost, time and energy when compared to the other methods of disease management. Hence, a study was under taken to screen the maize inbred lines and hybrids against the post flowering stalk rot of maize. Total of sixty two inbred lines and sixty hybrids were screened against charcoal stalk rot of maize. None of the screened genotypes showed resistant reaction to the disease. However, twenty four inbred lines viz., BML-6, CI-4, CI-5, CML-342, DML-16, DML-16-2, DMEI-165, DMEI-196, DMEI-207, DMEI-501, DMSC-36, GPM-114, GPM-496, GPM-549, GPM-622, HICI-1105, HICI-226, Indimyt 300 B, Indimyt 345-3, LM-13, LM-14, SKV-18, UML-1210 and twenty three hybrids CAH-153, CAH-1558, CAH-1566, CAH-1563, CAH-1570, CAH 1526, DKC 9141, DKC 9144, GH 1518, GH 1523, GH 1520, GH 1523, GH 1524, GH 1528, GH 1529, GH 1530, GH 1532, GH 1534, GH 1535, GH 1536, GH 1540, GH 1546 and GH 1547 showed moderately resistant reaction to the disease. Susceptible check G-25 had exhibited maximum rating scale of 9 indicating satisfactory level of disease development and the categorization of materials into different classes is appropriate.

In vivo evaluation of pigeon pea genotypes through different screening techniques against sterility mosaic disease

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One hundred and twenty three Pigeonpea (*Cajanus cajan* (L.) Millsp.) genotypes were collected from different sources and evaluated for their resistance against pigeonpea sterility mosaic disease (SMD) by adopting leaf stapling technique and infector- hedge technique in experimental plots maintained at AICRP on pigeonpea, ZARS, GKVK, Bengaluru. Among genotypes tested, nine genotypes namely BAHAR, BRG 3, ICP 7035, IPA 8F, IPA 204, BRG 14-1, MAL-13, ICPL 99099 and ICPL 99044 were found resistant (0-10 %). Six genotypes namely KPL 44, MA 6, BSMR 736, BSMR 846, ICPL 99091 and ICPL 99048 were moderately resistant (11-30 %). Rest of the 108 genotypes showed susceptible reaction (> 30 %). The maximum incidence up to 100 per cent was recorded in susceptible check ICP 8863. Among the two methods of screening tested under field condition, leaf stapling method showed slight maximum transmission compared to infector-hedge method.

Reaction of ridge gourd [*Luffa acutangula* (Roxb.) L.] local cultivars against downy mildew caused by *Pseudoperonospora cubensis* [(Berk. and Curt.) Rostow.]

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Ridge gourd is an important cucurbitaceous vegetable grown during both summer and rainy season. Ridge gourd fruits have high medicinal value and contain a good amount of fiber, vitamins and minerals which is considered good for diabetes besides it has diuretic, expectorant and hypoglycemic properties. It is affected by many fungal, bacterial and viral diseases such as downy mildew, powdery mildew, damping off and luffa mosaic virus. Among these, downy mildew caused by *Pseudoperonospora cubensis* [(Berk. and Curt.) Rostow.] is the most damaging disease that affect cucurbitaceous crops. Early infection of downy mildew can cause reduction in yield up to 60 %, whereas, late infection is less damaging. Management of downy mildew with systemic fungicide metalaxyl, lost the efficacy because of prevalence of resistance strains of fungus. So, breeding for disease resistance is one of the best and economical methods in combating downy mildew disease. In this study 41 genotypes including resistance check (Deepthi) and susceptible checks (Pusa Nutan and Pusa Nasdar) were subjected to natural screening in field conditions. In open field screening for downy mildew has led to identification of two resistant genotypes (COHRG-9 and COHB-32), two moderately resistant lines (COHB-10 and COHB-40) and one was highly susceptible (COHB-8) whereas remaining genotypes were exhibited moderately susceptible and susceptible reaction to downy mildew in ridge gourd. These resistant sources are being incorporated in breeding programme for downy mildew resistance in ridge gourd.

Evaluation of green long pre-breeding lines of brinjal (*Solanum melongena* L.) for bacterial wilt resistance, yield and yield attributing traits

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Ten pre-breeding lines of F_4 generation green long brinjal of Green Long x IIHR-3 along with their parents and checks (Arka Anand and Arka Kusumakar) were evaluated for bacterial wilt resistance after artificial inoculation and good horticultural properties. The results revealed that among 10 families of F_4 lines derived from the cross Green Long X IIHR-3 the progenies viz., 12-36-164-7, 12-36-164-10, 12-36-164-11 and 12-36-164-14 showed moderate resistance to the bacterial wilt disease, whereas, 12-36-46-3, 12-36-46-6, 12-36-164-1, 12-36-170-9, 12-36-170-11 and 12-36-170-19 found to be resistance. F_4 pre-breeding lines had shown a larger extent of variation for all the traits when compared to the interfamily variation, so there is a need of further advancement of generation to attain the homozygosity. The study lead to identification of superior green round brinjal plants resistant to bacterial wilt along with good horticultural properties from $F_{3:4}$ segregating population.

Host range studies of yellow mosaic disease of greengram [*Vigna radiata* (L.) Wilczek]

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Yellow mosaic disease caused by Mungbean yellow mosaic virus is one of the important constraints to greengram production. Information regarding other crops and weed hosts of MYMV is meager. The present study was conducted to identify the alternate hosts of yellow mosaic disease of greengram. In the present study several crops and weed hosts were cross inoculated with yellow mosaic disease of greengram under laboratory through insect vector whitefly (*Bemisia tabaci*). The results revealed that the causal virus of the disease was successfully transmitted from greengram to greengram (*Vigna radiata*), *Nicotiana benthamiana*, blackgram (*Vigna mungo*), horsegram (*Macrotyloma uniflorum*), pigeonpea (*Cajanus cajan*) soybean (*Glycine max*), cowpea (*Vigna unguiculata*) and weed hosts such as *Acalypha indica*, *Malvestrum coromandelium*, *Croton bonplandianum*, *Euphorbia geniculata*, *Alternanthera sessile* and *Phyllanthus madraspatensis*. While *Parthenium hysterophorus* did not show any symptoms. Weed hosts and crops infected with MYMV expressed the typical initial systemic symptoms of vein clearing. They typically produced the symptoms of vein clearing, light mosaic leaves, leaf puckering, mosaic, distorted leaves and finally they exhibited complete yellowing of leaves. While in case *Nicotiana benthamiana* severe leaf curling and distorted symptoms were noticed. This difference in transmission rates and expression of virus symptoms between crops and weeds could be due to whitefly preference and also host biochemical compositions which may interfere with virus multiplication. Thus, findings substantiate that the above hosts are major sources of the virus inoculum and served as potential alternate hosts of the disease during the off season.

Evaluation of green round pre-breeding lines of brinjal (*Solanum melongena* L.) for bacterial wilt resistance, yield and yield attributing traits

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Seven pre-breeding lines of F_4 generation green round brinjal of Raidurga Green Round x West Coast Green Round along with their parents and checks (Arka Anand and Arka Kusumakar) were evaluated for bacterial wilt resistance after artificial inoculation and good horticultural properties. The results revealed that four lines viz., 12-23-30-1, 12-23-30-2, 12-23-249-10 and 12-23-249-12 were found to be resistant among the pre-breeding lines. Two lines namely, 12-23-30-12 and 12-23-30-14 were shown moderately resistant reaction while, the line 12-23-249-2 was found to be moderately susceptible. Larger range of variation was observed for various quantitative characters in all the evaluated lines which indicated the need of further selfing to attain homozygosity in these lines. The study lead to identification of superior green round brinjal plants resistant to bacterial wilt along with good horticultural properties from $F_{3:4}$ segregating population.

A decade long experiences in development of soybean varieties with resistance to major diseases in India

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Soybean diseases are major stumbling blocks in successful raising of crop and achieving the highest productivity. Among the various management options available, breeding for resistance a long term and sustainable approach. In this, we summarise here the efforts made in development of resistant varieties of soybean against major diseases mainly rust, purple seed stain and pod blight complex. Rust in Karnataka was severe and caused losses up to 20-80 per cent in JS-335 depending on its severity, stage of occurrence and favourable climatic conditions in northern Karnataka. In recent years, soybean anthracnose has become one of the major production constraints in all soybean growing areas of India. The loss due to this disease in India has been reported to an extent of 16-25 per cent in seed yield apart from affecting seed quality. The research efforts on development and release of rust resistant varieties in India over a decade has lead to development and release of first ever rust resistant and high yielding variety DSb 21 for the state of Karnataka and also south India during 2013. Later, DSb 23 and DSb 28-3 highly rust resistant and high yielding varieties which have recommended for cultivation for Southern Zone (Karnataka, Maharashtra, TamilNadu, Andhra Pradesh and Telagana States) during 2015 and 2017. Out of 19 genotypes, the genotypes viz., DSb 12, DSb 20, DSb 23-5 and Kalitur were found highly resistant with a disease grade of one to pod blight complex. The genotype JS 335 was highly susceptible to anthracnose with a maximum disease grade of nine. Among the markers used, Satt 275 showed polymorphism for both the parents (EC 241780 and JS 335) as well as other genotypes. The amplified PCR product of genotypes with polymorphic marker Satt 275 was sequenced and most of the sequences scored an E value of 0.031 and an identity of 90 per cent with the mRNA sequence of the *Rpp5* gene. The classification results revealed that the sequence of the advanced line DSb 30-2 showed the highest degree of identity with the concerned *Rpp5* like disease resistance mRNA sequence.

Screening of chilli genotypes for resistance against powdery mildew caused by *Leveillula taurica*

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Powdery mildew of chilli caused by *Leveillula taurica* (Lev.) Arn. is a major constraint for chilli production in many chilli growing states of India. In severely affected plants, defoliation, reduction in photosynthesis and in drastic reduction of fruit yield is often observed. With an aim to search for resistance source against powdery mildew, seventy genotypes were evaluated under field conditions during *Kharif* and *rabi* 2015. Among seventy, the genotypes viz., DCA-1, DCA-2, DCA-3, DCA-4, DCA-5, DCA-6, DCA-7, DCA-8, DCA-9, DCA-10, DCA-11, DCA-12, DCA-13, DCA-14, DCA-22, DCA-23, DCA-24, DCA-25, DCA-26, DCA-35, DCA-42, DCA-44, DCA-45, DCA-57 and DCA-59 showed moderately resistant reaction during both *kharif* and *rabi* seasons and none of them were found resistant. However, remaining 43 genotypes were found moderately susceptible and other two susceptible check varieties Byadagi Kaddi and Byadagi Dabbi were found highly susceptible under field condition.

***In vivo* screening of finger millet varieties for blast resistance**

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Finger millet is commonly called “ragi” it is one of the important staple food crop of Southern Karnataka. In the recent years a significant yield loss in this crop has been reported due to the occurrence of blast diseases caused by *Pyricularia grisea*. This is necessitated to screening of new ragi varieties for resistance to commonly occurring diseases with special reference to leaf, neck and finger blast. In this back ground field investigations was conducted at AICRP on Small Millets, Zonal Agricultural Research Station, V. C. Farm, Mandya during *kharif* 2015 and 2016 for to screening of 12 released ragi varieties along with susceptible check Uduru mallige (Land race) were screened to assess the disease reaction by adopting standard scale and scoring technique. The pooled results revealed that, highest leaf blast disease grading was observed in the variety KM 252 (4.5 G) followed by KMR 301 (4.0 G) RAU8 (3.0 G) and PR 202 (3.0 G). The maximum leaf blast grade however, was observed in susceptible check Uduru mallige (5.0 G). The maximum per cent of neck blast was recorded in KM 252 (31.40%) followed by VR 708 (17.80 %) leading to their categorization as susceptible varieties. Similar trend as neck blast was observed for finger blast also where higher per cent incidence of finger blast was observed in KM 252 (32.50%) followed by RAU 8 (15.65 %). Apart from the above mentioned varieties rest of the varieties viz., GPU 28, GPU 48, GPU 67, L 5, KMR 204, GE 4440, VL 149 showed resistance reaction to neck and finger blast by recording 0.14 to 12.6% and 0.005 to 12.51 % incidence respectively compared to check variety Uduru mallige which is recorded 39.0% neck and 50.83 % finger blast incidence. As outcome of the experiment the resistant genotypes identified can be utilized as sources of resistance for future breeding programme.

Screening of soybean genotypes against soybean mosaic virus disease

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Soybean mosaic virus (SMV) is one of the most common viruses causing drastic reductions in seed yield and quality of soybean crop worldwide. Five hundred genotypes of soybean were screened against SMV under the field condition at ZARS, UAS, GKVK, Bengaluru, to assess the resistance of soybean genotypes. The per cent disease incidence was recorded at 30, 40, 50, 60 and 70 DAS. The genotypes were categorised by using 0-5 scale and the results showed that none of the genotypes were found immune to soybean mosaic virus disease. However, 46 genotypes were found resistant, 349 genotypes were found moderately resistant, 34 genotypes were found moderately susceptible and 14 genotypes were found susceptible to soybean mosaic virus disease and none of the genotypes were found highly susceptible to soybean mosaic virus disease.

Screening of soybean genotypes/ cultivars for their resistance to yellow mosaic virus disease

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Soybean is being grown extensively in Karnataka and it suffers from fungal, bacterial and viral diseases. Among viral diseases is major constraint in yield of soybean crop. The other viral diseases are soybean yellow mosaic (SYM), groundnut bud necrosis (GBN), soybean mosaic (SM), soybean pea mottle virus. Among yellow mosaic virus diseases, soybean yellow mosaic virus (SYMV), has been considered as an economically important disease which is limiting factor on crop growth and yield. Present study was conducted in under glass house condition through artificial whitefly transmission method in summer 2016 at GKVK, Bengaluru to identify the resistant genotypes against SYMV. Forty three genotypes/cultivars of soybean were screened for SYMV under glasshouse condition revealed that, none of the genotypes were found highly resistance to the disease. Eleven genotypes/cultivars viz., KDS-378, RKS-118, Bragg, DS-2706, DSb-25, Dsb-23, MAUS-2, DSb-21, DS-2708, DS-2006 and DS-2707 were found moderately resistance to soybean yellow mosaic virus (SYMV). JS-335 is highly susceptible to the soybean yellow mosaic virus disease.

Chemical induced mutations for development of resistance in banana cv. Nanjanagudu rasabale

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Induction of *in vitro* mutagenesis has become most important tool to enhance resistant traits of banana crop. The method being used to develop disease resistance lines in various susceptible banana cultivars but chemical mutations are widely accepted and yields positive mutants. There are several mutagens like Ethyl Methane Sulphonate (EMS) and Sodium Azide (NaN₃) available for banana crop improvement and each mutagen has its own important role as positive or negative effects on growth and development of banana plants. Explants from shoot tip culture of banana cultivar Nanjanagudu rasabale were treated with various EMS (0.30, 0.60, 0.90 and 1.20 %) and NaN₃ (0.01, 0.02 and 0.03%) concentrations. The putative mutants obtained after *in vitro* rooting were subjected for artificial inoculation with *Fusarium oxysporum* f. sp. *cubense*. Screening putative mutants for resistance to Panama disease was carried out by using syringe method of inoculation. It was observed that, putative mutants obtained from EMS were more susceptible (73.33 %) as compared to NaN₃ (44.44 %) treated explants. Among the NaN₃ doses, 0.01% found to produce 3 resistant lines during preliminary screening under greenhouse conditions. These putative mutants may serve as prepotent material for development of desirable mutants and needs to be further screened under field conditions and tested for acquired resistance traits.

Stability of disease resistance in Indian maize germplasm

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Maize is one of the most important food crop globally and a model system for the study of genetics, evolution and domestication. In India, the maize production is controlled by several abiotic and biotic stresses. Among the biotic stresses, Turicum Leaf Blight (TLB- *Exserohilum Turicum* (Pass) Leonard & suggs) and Southern Corn Rust (SCR- *Puccinia polysora* Underw) are the major threatening diseases under different ecosystems of southern India causing considerable yield losses directly and exposing the maize plants for stalk rots indirectly. Hence, management through resistant cultivars/hybrids remains the best option to increase the production and productivity levels of maize to meet the growing population. In view of this, the present study was aimed to identify stable resistant sources against TLB and SCR in Maize at AICRP, ZARS, V.C. Farm, Mandya (Hot spot location for TLB and SCR). A total of 119 maize inbred lines including susceptible checks with different genetic back ground were screened against these diseases for five consecutive years (2011-2015) during the rainy season of every year under artificial epiphytotic condition through leaf whole inoculation technique for TLB and spray inoculation of uredospores (ca.5X10⁵) of *Puccinia polysora* to the test material for SCR. Out of 119 inbred lines screened, only 19 inbred lines viz., NAI 137, 138, 142,161, 175, 176, 197, 204, 207, 209, 214, 226, CML 226, 248,360, 410, HKI 163, SKV 50, KUI 141 and KUI 141-A and seven inbred lines viz., NAI 138, 161, 175,197, 204, 207, 209 and CML 410 were showed stable resistance against TLB and SCR. Combined resistance reaction to both diseases was expressed by six inbred lines viz., NAI 138, 161, 197, 207, 209 and SKV 50.

Evaluation of mung bean lines for the resistance to mung bean yellow mosaic virus

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Mung bean Yellow Mosaic Virus (MYMV) is one of the most important diseases of Green gram in Karnataka. The virus belongs to the Begomovirus group and it is transmitted through whitefly (*Bemisia tabaci* (G.)) in nature. To identify the source of resistance to the virus, 13 mung bean lines developed at Asian Vegetable Research and Development Centre, Taiwan, were evaluated for the MYMV resistance and yield characters in the field during *Kharif* -2016. Among 13 lines tested, 4 lines viz; MYB-6, MYB-7, MYB-8 and MYB-9 showed least Per cent Disease Index 20.83%, 18.06%, 20.83% and 18.06% respectively. These lines were also further confirmed by Polymerase chain reaction using MYMV specific primer for the detection of MYMV. The virus was not detected in MYB-6, MYB-7, MYB-8 and MYB-9, whereas, the MYMV was detected at an amplified product of 900 bp in MYMV infected check green gram sample. Further, the four lines also performed well with respect to yield parameters viz; number of pods /plant, total pod weight and number of seeds per pod. The identified MYMV resistant lines can be used for the breeding programme to develop variety or for the improvement of the cultivated varieties with the incorporation of MYMV resistance.

Screening of brinjal accessions for bacterial wilt resistance

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Brinjal (*Solanum melongena* L.) is an important and widely consumed Solanaceous vegetable of India grown round the year. Among the diseases of brinjal, bacterial wilt is a major one caused by *Ralstonia solanacearum*, a soil and water borne pathogen, which limits brinjal production from 4.24 to 86.14 per cent, while in islands the disease is devastating in humid and congenial climate and can cause up to 100% losses. The disease occurs on all the type of soil, including sandy and clay soils. Bacterial wilt incidence was mostly prevalent in the acidic soils and in the coastal humid areas. High temperature and moisture are favorable. The external symptom of the infected plants are wilting, stunting and yellowing of the foliage. The internal symptoms are progressive discoloration of the vascular tissue, mainly the xylem at early stages of infection and of portions of the pith and cortex as disease develops until complete necrosis. The soil and water borne nature of the pathogen, conventional management strategies of bacterial wilt like crop rotation, adjusting the date of planting, cultural methods and soil treatment with chemicals are not effective, especially for its broad host range. The use of resistant cultivars is widely recognized as the safest, most economical and most effective method for protecting crops from disease. Sixty brinjal accessions were screened in nursery by artificial inoculation with *Ralstonia solanacearum* culture at the concentration of 1.0×10^8 cfu /ml (0.3 OD at 630 nm). The accessions were categorized as highly resistant to highly susceptible depending on the percentage of wilt of the plant. The accession CARI-1, Surya, WCGR, IIHR-3 and S-75 showed highly resistance against the bacterial wilt. The accession Rampura local and IIHR-586 showed highly susceptible. Accessions found to be highly resistant in the present study are being further used in breeding programs for developing bacterial wilt resistant eggplant hybrids.

Antioxidant-mediated survival strategy in primed ragi plants against blast disease

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Ragi blast caused by *Magnaporthe grisea* (Hebert) Barr. is a very severe disease with a subsequent annual loss of ~ 80% yield. It is highly virulent with a wide host range (rice, wheat, rye, barley and pearl millet). Many strategies have been used to manage the disease, of which, use of beneficial, soil microbes is an eco-friendly approach for induced systemic resistance (ISR). It is the state of the plant wherein the selected rhizobacterial strains enhance the ability of the plant to mobilize infection-induced cellular defense responses against the pathogen (priming). The synergism between the plant and rhizobacteria plays a crucial role in host-specific disease resistance by many of those mechanisms or signals. Inoculation of bacteria that protect plants through different mechanisms in pathogen-challenged plants, contributes to the increase in knowledge on plant-microbe interactions. Antioxidants act as signal molecules which subsequently enhances cellular patterns of the host, thus increasing resistance during the early hours of pathogen entry. The goals of the present study were (i) to analyse the performance of rhizobacteria for growth promotion and induce disease resistance under green-house conditions in ragi plants and (ii) to analyse the enhancement of disease resistance by measuring the antioxidant levels at different time (0, 6, 12, 24, 36, 48, 72, 96 hours post inoculation) intervals. Isolated rhizobacteria were identified as fluorescent *Pseudomonas* by partial 16sRNA sequencing. Two isolates, JUPC113 (GenBank ID. KX010601) and JUPW121 (GenBank ID. KX010602) were used in priming the ragi (Indaf 9) seeds. Plants challenge-inoculated with *M. grisea* spores (5×10^4 spores.mL⁻¹) showed reduced disease incidence in plants from primed-seeds, compared to the control. JUPC121 (92.03 ± 0.04%) showed enhanced disease protection rate with vigour index of 3064.00 ± 3.06, disease incidence was highest in control (2.67 ± 0.3) plants and vigour index of (2005.33 ± 3.71). Primed and control samples were analysed for various antioxidants, which showed increase in activities of superoxide dismutase (SOD), ascorbate peroxidase (APX), peroxidase (POD), glutathione reductase (GR), catalase (CAT). A decrease in malanoldialdehyde (MDA) and proline content was observed in plants from primed seeds, which was comparatively significant. The native PAGE showed alterations in the intensity of the isozyme bands in control plants. From these studies, the xymogram and enzymatic assays indicates the induction of disease resistance, thereby sinking the disease severity. Hence, the microsymbiont, reinforce the disease resistance and protect the primed plants from *M. grisea* against the detrimental effect, a useful strategy for ragi production by sustainable agriculture.

Morphological and morphometrical studies of *Meloidogyne graminicola* under different soil types of major rice growing states of India

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Of late, rice root-knot nematode (*Meloidogyne graminicola*) has emerged as a major threat throughout the world and it has occupied a place of 'National Pest' owing to its severity. This is a major constraint in successful rice cultivation leading to significant loss to the rice grower. Studies were carried out with respect to morphology, morphometrics, identification of races, survival strategies under different soil and moisture regimes, galling pattern, biology and management using biocontrol agents. Morphological and morphometrical comparisons were made for 12 populations of *M. graminicola*, collected from different agro-ecological regions from India namely, Gujarat, Hyderabad, Assam, New Delhi, Odissa, Uttar Pradesh and different districts of Karnataka viz., Shivamogga, Mandya, Davanagere, Chikmagalur, Kodagu and Udupi in respect of eggs, second stage juveniles and females by employing Duncan's Multiple Range Test and Multivariate Analysis with standardized canonical discriminant function. Out of 12 *M. graminicola* populations, three populations namely, New Delhi, Shivamogga and Hyderabad appeared quite different from typical *M. graminicola*. In host range studies, all the tested cultivars were infected by *M. graminicola*, except cotton and bhendi where no galls were observed on these cultivars. However, North Carolina tomato cv. Rutgers infected by this *M. graminicola* hence, it is an indication of occurrence of new species/race in this location. Survival of *M. graminicola* studies revealed that, the location having sandy loamy soil, acidic soil pH, with least soil organic carbon, higher nitrogen, lower phosphorous and potassium with higher moisture content in the soil recorded higher nematode population. While, least was recorded in clay loamy soil with alkaline pH, higher soil organic carbon, lower nitrogen, phosphorous and higher potassium and low moisture content. Different galling patterns were observed from different locations, they are the indication of new races/ species in rice. In biology study, second stage juveniles were attracted to the roots and moved towards the root tip. The infective second stage juveniles of *M. graminicola* entered the rice roots within 24 hrs of inoculation and they started feeding and became stationary. The duration of second, third, fourth and adult female stages lasted for 1-5, 6-8, 9-12 and 28 days respectively. The total life cycle including the preparasitic stage was 25-28 days. Among different bioagents tested, application of consortium of *P. fluorescens* + *T. harzianum* was found effective in reducing the incidence of *M. graminicola* with highest B: C ratio of 1.28.

Isolation, characterization and evaluation of fungal endophytes as potential biocontrol agents on *Sclerotium rolfsii* sacc. infecting *Capsicum annuum* L.

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Increased usage of plant protection chemicals in the management of plant diseases lead to the development of resistance strains among pathogens, environmental pollution and finally fall in benefit-cost ratio due to increased cost of cultivation. To combat these issues, evaluation of biocontrol agents against soil borne pathogen *Sclerotium* sp. infecting chilli was carried out using hidden world organisms called fungal endophytes. Fungal endophytes are living microorganisms present inside the plant tissues imparting tolerance against abiotic and biotic stress, in turn getting food and livelihood from plants. Exploration of fungal endophytes as potential biocontrol agents against *Sclerotium* sp. infecting chilli was made by conducting *in-vitro* studies. Fungal endophytes isolated from selected plants with antimicrobial activity *viz.*, *Hibiscus rosa sinensis*, *Phyllanthus acidus*, *Catharanthus roseus*, *Phyllanthus amarus* and *Solanum torvum*. Total 66 fungal endophytes were obtained from 165 processed tissue segments, morphologically categorised into 25 Operational Taxonomic Units (OTU's) and evaluated against *Sclerotium* sp infecting chilli by dual culture technique. Out of 25 OTU's, 5 OTU's showed greater than 50 per cent and 20 OTU's showed 1-50 per cent inhibition. Endophytic OTU HI2 from *H. rosa sinensis* showed highest per cent inhibition (65%) of *Sclerotium* sp. was taken for further studies. Molecular characterization of *Sclerotium* sp. infecting chilli and endophytic OTU HI2 by amplifying Internal transcribed spacer (ITS) region (ITS1 and ITS4 primers) revealed *Sclerotium* isolate as *Sclerotium rolfsii* and OTU HI2 as *Trichoderma asperellum*. To decipher the mechanism involved in inhibition of *S. rolfsii* by *T. asperellum* broth culture study and double plate assay for diffusible and volatile metabolites were conducted. The metabolite profile of high pressure liquid chromatography (HPLC) analysis showed that the metabolite content of the endophyte was eluted between 21-39 min retention time. Major peaks were observed between 21 to 25 min and 36 to 39 min retention time. In case of pathogen the metabolite peak was eluted at 24 min of retention time. Few metabolite peaks observed individually for pathogen and endophyte were absent in the samples processed from interaction between pathogen and endophyte. However, two peaks were obtained at 37.5 and 39.4 min retention time, which were not observed in the samples with pathogen or endophyte alone. In double plate assay the volatile organic compounds (VOC's) generated by the endophyte inhibited the mycelial growth of pathogen (56.46 %) significantly over control. Analysis of antimicrobial VOC's produced by *T. asperellum* by Gas Chromatography-Mass Spectrometry showed varied peaks. Total thirty-four VOCs were obtained from the potato dextrose agar media (control), endophyte, pathogen and interaction (endophyte and pathogen) in double Petri dish assay treatments. Fourteen tentative VOC's are specific to *T. asperellum* and four VOC's specific to *T. asperellum* and *Sclerotium rolfsii* interaction were detected (Epizonarene, Guaiol, á-Eudesmol and Verticilla-4 (20), 7, 11-triene). In host colonization assay *T. asperellum* successfully colonized in chilli stem and root tissues.

Metabolic reprogramming in leaf of wild tomato provides resistance against *Alternaria solani*

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Alternaria solani causes early blight (EB) disease in tomato affecting its yield in tropical environment. Wild relatives such as *Solanum arcanum* might have a potential source of EB resistance. However, molecular mechanism for EB resistance largely remains unexplored. We explored non-targeted metabolomics on resistant and susceptible *S. arcanum* accessions upon *A. solani* infection to unravel metabolic modulation. More than 2000 putative potential metabolites were detected of which over 600 depicted significant changes in resistant and susceptible accessions. Majority of these EB-triggered metabolic changes were in steroidal glycol-alkaloids, lignins and flavonoids. This was in accordance with biochemical and gene expression studies of key enzymes from these pathways indicating their potential role in EB resistance. Interestingly, *S. arcanum* rWRKY1, a known transcription factor, physically interacted with MYB20 promoter in sequence-specific manner leading to activation of required defense metabolites. Overall, this study highlights key roles of steroidal glycol-alkaloids as phytoalexins and phenylpropanoids along with lignin accumulation as potential mechanistic basis of EB resistance in wild tomato.

Molecular analysis to identify genomic regions controlling blast resistance in segregating generation of the cross rajamudi × BR-2655 in rice (*Oryza sativa* L.)

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Rice (*Oryza sativa* L., 2n=24) is one of the world's most important cereal and it is staple food for one-third of the world's population. Rajamudi is a popular traditional rice variety (TRV) of Karnataka with good cooking properties. However, the yield potential of this variety is very low because of blast susceptibility caused by *Pyricularia oryzae* Cav. Hence the present study was undertaken to improve blast resistance in rajmudi. It is crossed with resistant variety BR-2635 and segregating generation was developed. Molecular analysis were done to identify the transgressive segregants with blast resistance using the total of eight disease linked markers, three were polymorphic between the parents rajamudi and BR-2655. This study confirms the presence of three blast resistance genes viz., *Pish*, *Pi-38* and *Pi54* in BR-2655. The three markers viz., RM3825, RM206 and Pi54 Indel showed polymorphism between rajamudi and BR-2655 were used to screen the F₃ individuals for presence *Pish*, *Pi-38* and *Pi54* genes. There were eleven triple positive plants identified among the F₃ individuals selected for screening. Hence these markers can be used to complement classical breeding techniques in order to select segregating plants at early stage itself based on the DNA marker genotype rather than phenotypic disease screening and also these individuals can be used for produce blast resistant varieties.

Endophytic fungi mediated induction of systemic resistance in pearl millet against downy mildew

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Endophytic *Trichoderma hamatum* isolated from pearl millet roots was evaluated for its efficiency to suppress downy mildew disease. *T. hamatum* seed treatment resulted in systemic and durable immunity against pearl millet downy mildew disease under greenhouse and field conditions. *T. hamatum* treated seedlings responded to downy mildew infection with high lignification and callose deposition. RT-PCR analysis revealed differentially expressed transcripts of the defense enzymes and PR-proteins in treated, untreated, and checks, wherein, PR-1, PR-5, and cell wall defense HRGPs were significantly over expressed in treated seedlings as against their lower expression in controls. *T. hamatum* treatment significantly stimulated endogenous salicylic acid (SA) levels and significantly up regulated important SA biosynthesis gene isochorismate synthase. The results indicated that *T. hamatum* UoM13 treatment induces resistance corresponding to significant over expression of endogenous SA, important defense enzymes, PR-proteins, and HRGPs, suggesting that SA biosynthetic pathway is involved in pearl millet for mounting systemic immunity against downy mildew pathogen.

Culture filtrate effect and pathogenic variability of isolates of *Fusarium oxysporum* on fenugreek

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Fenugreek (*Trigonella foenum graecum* L.) is an important seed spice, originated in South-Eastern Europe belonging to the family Fabaceae. Although many diseases are reported in fenugreek, wilt caused by *Fusarium oxysporum* is becoming more severe in recent years. Maximum growth of *F. oxysporum* was attained on 14th day after incubation (393.33 mg) beyond which autolysis occurred. Among 20 isolates, Fo NES (89.50%) showed maximum per cent of seed germination and also root and shoot length which differed significantly with other isolates indicating low quantity of toxin production. Complete failure of seed germination was observed in isolates viz., Fo YAT, Fo GOV, Fo BAN, Fo GAN and Fo SOM with maximum toxin production. Higher seedling vigour index was noticed in Fo NES isolate (1337.91) followed by Fo NAR (1291.78). Whereas, the isolates like Fo YAT, Fo GOV, Fo BAN, Fo GAN and Fo SOM recorded zero vigour index, indicating high quantity of toxin production. With respect to pathogenic variability, cent per cent disease incidence was recorded in all isolates of *F. oxysporum*. Maximum degree of virulence index was recorded in Fo YAT (3.57) which took less number of days (28) for complete wilting of plant followed by Fo BAN and Fo SOM (3.13) required 32 days for wilting. However, Fo HEB and Fo NES was found to be less virulent with minimum virulence index of 1.67 and took maximum days (60) for complete wilting of plants.

Technical Session II

Impact of changing climate on plant diseases

Influence of weather factors on nematode fungal wilt complex

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The influence of various weather factors viz., rainfall, no. of rainy days, maximum and minimum temperature, relative humidity, were assessed for incidence of wilt complex disease on black pepper was assessed during survey (2013-14). During survey, among all the five districts, maximum *R. similis* population (37401) was recorded in Mudigere taluk of Chickmagalur district. A total rainfall of 3604.38 mm was recorded in Mudigere taluk with 101 numbers of rainy days and maximum rainfall 1439.49 mm rain fall was during July month with 28 rainy days. An average temperature of 23.10°C to 19.85°C was recorded with constant average temperature 19.00°C to 20.20°C was recorded from July to October and the relative humidity range 85.03 per cent to 95.80 per cent was recorded during July month. Similarly, in Somavarpete taluk, *R. similis* population (33237) recorded during survey. The taluk had received annual rainfall of 3468.13mm in 98 rainy days and maximum rainfall of 1634.65 mm was received during July month with 30 days of raining. An average temperature of 14.23°C to 29.55°C was observed with 17.60°C to 23.25°C was recorded during August month. An average relative humidity of 76.16 per cent to 99.95 per cent was recorded with 100 per cent relative humidity observed during July and August. In Thirthahally taluk of Shivamogga district, *R. similis* population was 32159 during survey and the taluk had received total of 3788.64 mm rainfall with 123 numbers of rainy days. Maximum rainfall of 1736 mm was recorded during July months and rainfall was equally distributed in all the days of month. The taluk has average temperature range between 17.84°C to 31.55°C with average maximum and minimum temperature during July was 17.40°C to 26.10°C with relative humidity 83.97 and 100 per cent respectively. In Shivamogga taluk, minimum number of *R. similis* population was recorded with minimum 1043.29 mm and maximum rainfall of 381.07 mm rainfall was recorded during July with temperature 20.50°C to 28.90°C and relative humidity ranges from 83.46 per cent to 97.00 per cent respectively. From all these parameters, it was confirmed that amount of rainfall, number of rainy days, temperature and relative humidity favors *R. similis* development and multiplication.

Impact of climate on the development of turcicum leaf blight of maize

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Maize is one of the major cereal crop grown in India and its cultivation is gaining momentum in most of the states in India as food, feed and industrial crop. Maize crop grown in India face extreme climatic conditions and a number of biotic constraint which results in reduction in productivity of subtropical maize. Among the biotic constraints, Turcicum leaf blight caused by *Exserohilum turcicum* (Pass.) Leonard & Suggs is a serious and destructive disease during *Kharif* season. Most of the hybrids grown are prone susceptible to this disease inflicting heavy losses under favorable weather conditions. A field experiment was conducted to study the influence of climate on the severity of turcicum leaf blight of maize during *Kharif* 2016. Initially in the 30th standard metrological week, disease index was 21.5 per cent and gradually increased to 52.8 per cent on 34th standard week when the crop was at tasselling stage. Maximum disease severity was observed at dough stage ie at 39th standard week (76.3 %). This higher disease severity coincided with heavy rainfall ie., 55.8mm which resulted in high relative humidity (89 %) and low minimum temperature (20.5°C). The total amount of rainfall received during August month was 117.2 mm with more number of rainy days (11) which resulted in high atmospheric moisture and long leaf wetness period. These factors were found highly favorable for development and fast spread of disease. The studies revealed that maximum temperature between 24-28°C, minimum temperature between 19-21°C combined with more than 85% relative humidity, intermittent rainfall and 2-4 rainy days per week was highly congenial for turcicum leaf blight development, spread and epidemics. Sowing of maize in the third week of July and afterwards tend to become more prone to disease susceptibility.

Effect of carbon dioxide on dry root rot of chickpea caused by *Rhizoctonia bataticola*

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Dry root rot caused by *Rhizoctonia bataticola* (*Macrophomina phaseolina*) of chickpea (*Cicer arietinum* L.) is gaining importance in the changed climatic condition when growing crop is predisposed to high carbon dioxide. Being mainly a soil-inhabiting pathogen, many environmental and soil factors are responsible for the development of disease. Now a day's with changing climatic condition plant-pathogen system is also changing. Carbon dioxide is one of the main factor in fluctuation of diseases in crops; To study the effect of Carbon dioxide on chickpea dry root rot diseases, the experiment was conducted under three sets of treatments under Open Top Chamber (OTC). The incidence of dry root rot was more severe in case of the treatment elevated CO₂ condition of 550 ± 25 ppm with 2 °C rise in normal temperature. In this case, early death of plants occurred due to rotting of roots under soil here we had seen the severe infection and root and drying of plants, Followed by elevated CO₂ condition of 550 ± 25 ppm with normal temperature, where severe infection was but it noticed slowly progressed drying of leaves and plants and less incidence was found in ambient CO₂ condition of 390 ± 25 ppm CO₂ with normal temperature and open environmental condition, where disease was present at later stage of the crop growth, but there was no drying or death of the plants.

An overview on effect of changing climate on plant diseases

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Globally plant diseases and pests including postharvest diseases cause around 42% loss in production of important food and cash crops. Besides direct losses, the chemical plant disease control measures can also result in environmental contamination, residue in food including socio-economic problems that adds gravity to the impact of plant diseases. The plant disease is an interaction between host, pathogen and environment including weather and climate. Shifts in any of these components can dramatically effect the magnitude of disease expression on temporal and spatial scale in a given pathosystem. The impacts of climate change can either be positive or negative or neutral. Climate change may further influence the co-evolution of plants and their pathogens. Plant pathogens are ubiquitous and they are the first to demonstrate the effects of climate change and hence they constitute a fundamental group of biological indicators. The impacts on plant diseases can neither be easily measurable nor be easily predictable, therefore their study require multidisciplinary approach. The possible approach would be by using future climate forecast models in association with disease simulation models. The effects of increasing concentrations of greenhouse gases including atmospheric CO₂ on incidence of plant diseases and their chemical or biological control will be the major thrust area in future. Elevated CO₂ concentration known to increase photosynthesis, leaf area, plant height, total biomass (shoot and root), sugar and starch content, water-use efficiency and yield that in turn alter the plant architecture by development of larger plant phenotypic organs which favours foliar pathogens. Similarly, increased moisture content is known to increase incidence of *Pythium*, *Phytophthora* and *Sclerotium* in tropical regions. Increased diurnal temperature difference coupled with reduced night temperature may favour the powdery mildews. Climate change may affect both host plant and insect-vector populations, thereby affecting the spread of plant viruses. Although elevated CO₂ levels have been shown to have little direct effect on natural enemies of insect herbivores, they can indirectly influence the third trophic level. Climate change adds an extra layer of complexity to plant protection in days to come.

Plant disease research strategies under changing ecological conditions

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India's agricultural biosecurity relates to the livelihood security of nearly 70 per cent population. India's consignments of farm exports are rejected in hundreds every year on the grounds of mycotoxin, Salmonella, pesticide residues etc. Without proper biosecurity, perhaps food security is doubtful. There is need for a comprehensive biosecurity policy to safeguard the income and livelihood of the farm sector, to enhance national capacity for risk analysis and to monitor, warn, educate and build infrastructure for containment of pandemics. New variants or pathotypes continue to emerge or enter due to evolution of pathogen, international travel or alterations in climate. Enhanced opportunities are available to assess the genetic variation of pathogen to provide a greater insight in breeding for disease resistance. The variations of *Fusarium solani* causing wilt of chilli and wilt of pigeonpea is described here. Mycotoxin of food commodity is a serious problem. The International Agency for Research on Cancer classified aflatoxin as group-I human carcinogen. There is need to develop low cost detection of aflatoxin then identify the aflatoxin risk prone areas for management.

The research on Plant Growth Promoting Rhizobacteria should focus on identification of potential isolates with multiple antibiotic producing genes, induced systemic resistance compatibility with pesticides, formulation, shelf life and their delivery for large scale application. Identification of useful biocontrol agents capable of degrading pesticides residues is essential for their exploration. In view of the inherent safety and long term social and environmental benefits of their evaluation and registration shall be taken out from the purview of insecticides Act-1968 and Bio-pesticide act. The research on *Trichoderma* shall be oriented towards development of isolates enduring salinity, drought, high temperature and compatibility with pesticides.

Proteomics and genomics will become a cornerstone of Plant Pathological research, facilitating study of complex interactions among pathogen, host and environment. A basic study of proteomic in pigeonpea-Fusarium interaction has revealed the presence of TLP proteins. Establishment of model plant health clinics for providing efficient and accurate diagnostic service using E-pest surveillance system is another workable model. Success story of IPM demonstration on chilli under farmers field as a participatory approach with judicious use of pesticides, bioagents, botanicals and other IPM interventions from preventing untold ecological damage is discussed herewith.

The importance of the environment on the development of plant diseases has been known for over two thousand years. Diseases are responsible for losses of at least 30 % of global food production. There is close relationship between the environment and disease. Climate change will cause modification in pathogen infection and host interaction with pathogen. Climate factors like increase in temperature, ozone depletion increases the necrotrophic pathogens and climate factors like moisture, elevated CO₂ increases the biotrophic pathogens. High temperature, precipitation, relative humidity might increases survival ability and fitness of the pathogen. Plants become more susceptible to rust diseases with increased temperature. Diseases like apple scab, late blight and vegetable root pathogens are more infectious to plants with increased moisture. Increased CO₂ concentration resulting greater fungal spore production. Ozone exposure tends to decreases the incidence of diseases caused by obligate pathogens but increases incidence of diseases caused by facultative pathogens.

Most common method of plant disease management is chemical method. Change in duration, frequency and intensity of rain alters the efficiency of fungicides. Since they can quickly washed away. The temperature influences degradation of fungicides and pesticides. Pathogen lifestyle, reproduction, activities and activity of biological control agents can also influenced by environment factors. The mode of disease development is different in different climatic conditions. Different climate requires different management strategies. The analysis of potential impact of climate change on plant disease is essential for the adaptation of control measures as well as for the development of resistant cultivars, new control methods or techniques in order to avoid more serious losses.

Integrated pest management in changing climate: Need for paradigm shift

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Impact of biotic stresses afflicting crops of economic importance has taken a central stage, particularly in the backdrop of increasing globalization of agriculture. The trans-boundary diseases not only adversely affect agricultural productivity but also act as serious barriers to trade. Assessments made over the last ten years have indicated that the threats are real and the risk is moderately high for unintentional introductions of pathogens and pests. Risk assessments include an evaluation of the vulnerability of the region's plant system, the probability of introductions, and the severity of consequences resulting from those introductions. Equally important is the evolution of new races and biotypes of native pathogens and pests under altered climate change. The urgent need for crop management within the ambit of IPM has, therefore, gained new importance. In this emerging scenario, the tools of biotechnology have also become pivotal elements.

Over the years, plant protection research has, no doubt, witnessed significant advancements. However, with the changing cropping systems coupled with the impact of climate change on host-pathogen interaction warrants new paradigm shift to manage plant diseases and pests effectively. The major components of maintaining plant health can be categorized as: use of disease-free seeds and other planting materials; sanitized and optimally fertilized soil; appropriate irrigation practices, and the use of products and practices to protect the crop against biotic pressures. Biotechnology can greatly facilitate in all these stages of plant protection by practices as diverse as using diagnostic methods to certify the health of seeds and planting materials, detection of pesticide-resistant strains of pathogens and the development of plants resistant to pests/pathogens. Besides, the use of molecular tools to detect plant pathogens, disease progression or resistance to pesticides, biotechnology approaches have also been valuable for pathogen taxonomy. No doubt, researches have gained insight into the biological nature and epidemiology of major diseases and pests, still there exist gaps in understanding and implementing the optimal management of biotic stresses afflicting crops. Emergence of new exotic pathogen races / strains has made their presence in different agro-ecological situations. Serious efforts need to be launched to understand the genetic structure of pathogen populations, - so important for breeding durable resistance to major biotic stresses of plants.

Establishment of plant biosecurity system would address the impact of climate change on plant diseases and pests, requiring the capability for early detection, reliable diagnosis and rapid response. Success will depend on effective cooperation among the state-level plant health professionals, agricultural universities and public stakeholders. It would be appropriate to establish plant diagnostic network for data capture and analysis capabilities for rapid identification of disease/pest outbreaks. Tailoring workable IPM modules have, therefore, gained primacy.

It is equally important to train and re-train new generation of human resource in the frontline areas of plant protection. In this changing world one cannot work in isolation, like host-pathogen interaction, where many coordinate processes work together for compatible or incompatible interactions. We too have to work in a network mode, drawing experts from various related disciplines, crossing trans-discipline boundaries and working for the better management of biotic stresses for sustainable crop production and productivity.

The possible impact of climate change, particularly changes in the levels of carbon dioxide, and ozone will substantially influence disease by modifying host physiology as well as host resistance. Similarly shifts in precipitation and temperature will influence disease epidemiology. Experimental research on different disease systems is, therefore, necessary to tailor appropriate IPM modules.

A dynamic equilibrium between problem-solving research to the development and implementation of problem-solving approaches is required. The issue that must be addressed is to re-establish the problem-solving continuum where it has been weakened, particularly in the context of global climate change.

Climate change and fungal biodiversity

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The Variability among living organisms and the ecological complexes of which they are part, includes ecosystem, species and genetic diversity. Resilience and flexibility of ecosystems correlate positively with diversity. Climate change means scientific consensus like green house gases have caused warming of the global average temperature, raising sea levels and otherwise affecting natural systems.

Estimates of future extent and Impacts range of approximately, 1^{1/2} to 6° degrees by 2100 severely impact on fresh water, agriculture and nature system. The relationships between the issue areas like biodiversity – affect forest composition and services, supports adaptation to climate change where as forest - supports biodiversity regulate climate impacts preserving large intact forest ecosystem will increase the ability of species to naturally adapt to climate change and there by lessen the impact on Biodiversity. Climate change in Biodiversity- Range shifts generally from north and upslope changes in community and species relationships and Phenological changes.

Cultural and morphological variability of finger millet blast (*Magnaporthe grisea* (Hebert) Barr. from different regions

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Blast caused by *Magnaporthe grisea* (anamorph = *Pyricularia grisea* (Cooke) Sacc.) is the most destructive disease. The leaf blast samples from Ranichouri, Ranchi, Almora and Bengaluru were collected, From each location, 10 monoconidial isolates were isolated by following standard protocol. For cultural variability twelve different media were used for the growth of *Pyricularia grisea* viz., oat meal agar, ragi yeast lactose agar, Mathur's medium, host extract + sucrose, ragi leaf medium, ragi meal medium, peptone dextrose medium, malt extract medium, rose bengal medium, Czapek's dox medium, Richard's medium and potato dextrose agar medium. Among these ragi yeast lactose agar was found to be significantly superior for growth (8-8.5cm) and sporulation (>12 conidia/microscopic field) of *P. grisea* compared to other media with circular to irregular and slightly wavy colonies having course and smooth margins. Most of the isolates sporulated well on ragi yeast lactose agar meium on 7-13 days. The conidia were pyriform, either large, medium to small in size having rounded base and the pedicel narrowed towards the pointed tip. Variations in morphological characters of different isolates were observed with respect to colony colour (grayish black to buff, black, black and white), diameter (7-9 cm), sporulation (7-13 days), number of conidia per microscopic field (5-40) and size of the conidia (23.20×6.40 to 3.80×1.50 µm). These variability studies on finger millet blast pathogen helps to know requirements for the growth and development of the pathogen and its sporulation which can be made use of in understanding variability of the blast pathogen which helps for screening for disease resistance to this disease.

Management of late blight and identification of A2 mating type of *Phytophthora infestans* in potato

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Phytophthora infestans is highly variable and very much adapt to the newly bred varieties and fungicides. In India, A2 mating type has displaced the A1 in temperate elevated lands and also in sub-tropical plains. In this background, an experiments was initiated during *Khariif* 2016 at Horticulture Research and Extension Station, Hassan under southern dry zone of Karnataka. Without any plant protection measures, the crop was sown at 60 cm X 20 cm spacing with soil application of recommended dose of fertilizers of 75:75:100 kg NPK/ha and FYM of 25 t/ha. The sowing operation was taken up at different dates as early, middle and late sowing. The data indicated that, early sowing (third week of May) noticed 22.22 per cent disease index (PDI) at 80 days after sowing with marketable tuber yield of 8.79 t/ha and rottage tubers of 0.48 t/ha, having aea under disease progress curve (AUDPC) value of 626.64 followed by middle of sowing (second week of June) recorded 32.23 per cent disease index of late blight at 63 days after sowing with marketable (6.36 t/ha) and un-marketable tuber yield (1.19 t/ha), besides rottage tubers of 0.56 t/ha with AUDPC value of 836.08. Therefore, it was concluded that, early sowing noticed lowest late blight index with higher marketable tuber yield, with better disease escape and found suitable time for sowing in Hassan and Chikkamagaluru districts during *Khariif*. Further, in Karnataka revealed frequency distribution of *Phytophthora infestans* was 20 per cent in A1 and 80 per cent in A2 mating type. Therefore, it was concluded that A2 mating type was replaced by the A1, which shows best adaptability to potato bred varieties and resistance to metalaxyl fungicide.

Technical Session III

**Recent advances in detection and
diagnosis of plant diseases**

Thrips as a vector of bud necrosis in groundnut

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Thrips (Order: Thysanoptera) has revealed a complex relationship between the virus, vector, plant host and environment. They are small insects that live in the flowers and folded leaflets initially resulting in white patches on the upper and necrotic patches on the lower surface of leaves. Thrips cause significant direct damage to plants, but their transmission of tospoviruses is most difficult to control and frequently causes the most severe damage to crops. At least ten species of thrips transmit tospoviruses, all of which are in the Thysanopteran family Thripidae. Most thrips vector species deposit their eggs into plant tissue and the eggs hatch after 2–3 days, depending on temperature and plant host. Both larval and adult stages of thrips vectors can actively feed on virus infected host plants, but only early larval instars can acquire the virus and later instar larvae and adults arising from such immatures can transmit the virus after a latent period. Adult thrips can acquire tospoviruses, but they do not transmit them. This is presumably because of insufficient multiplication in the midgut, a lack of movement to salivary glands and a lack of multiplication thereafter. Thus, each new generation of thrips vectors must acquire the virus as larvae. The study of virus vector interaction is important in managing tospoviruses, because only the plants that serve as hosts for both the insect and the virus are important in epidemics.

Effect of different media on cultural diversity of *Rhizoctonia bataticola*, inciting dry root rot of groundnut

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Eleven different media including synthetic and semi synthetic in solid and liquid state were tested for their suitability to grow and sclerotial formation of the test fungus *Rhizoctonia bataticola*. Among the synthetic media, growth of *R. bataticola* was significantly more in Richard's media (8.73 cm) followed by Czapek's agar medium (7.93 cm). Potato dextrose agar (9.00 cm) was the best non synthetic media which was on par with potato carrot agar (8.87 cm). Among the non synthetic media, dry mycelial weight of *R. bataticola* was more in potato dextrose broth (512.00 mg) followed by oat meal broth (468.90 mg) whereas, Richard's medium was the best non synthetic media which encouraged the sclerotial production and maximum dry mycelial weight (467.84 mg) followed by Czapek's broth (309.62 mg).

Molecular diagnosis of Chivmv causing mosaic in capsicum (*Capsicum annum* var. *grossum* sendt)

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Viral diseases are considered to be the major limiting factors in *Capsicum* (*Capsicum annum* var. *grossum* sendt) production. *Chili veinal mottle virus* (ChiVMV) is one of the important viruses, which decrease yield significantly. The survey was conducted during *rabi* 2015-16 to determine the prevalence of incidence of mosaic disease in major capsicum growing districts namely, Chikkaballapura, Kolar, Bengaluru rural and Ramanagar. The per cent incidence of mosaic disease based on symptoms in field was noticed highest in Ramanagar (54.85 %) and the least incidence of mosaic disease was observed in Chikkaballapura (26.85 %). The symptom includes yellowing, mosaic and mottling and the virus was preliminarily confirmed by DAC-ELISA. Among the 40 samples, 30 samples were reacted positively with ChiVMV antiserum and the remaining were reacted with CMV. The ChiVMV was later maintained in *Datura metel* and the ChivMV infection was confirmed by the amplification of coat protein gene using RT-PCR. The nucleotide sequence similarity of Kolar (KOL-1) isolate found to be 93.81 per cent with ChiVMV isolate CHM15 Raichur Karnataka (EF213688.1) followed by ChiVMV isolate Be16 Bellary Karnataka (EF213683.1) and the lowest nucleotide homology of KOL-1 isolate found 78.31 per cent with ChiVMV isolate ATIPK Pakistan (KJ472764.1) and percentage of nucleotide homology of Chikkaballapura (CHB-1) isolate found to be 93.97 per cent with ChiVMV isolate RAJ Rajasthan (KJ000073.1) followed by ChiVMV isolate ChiVMV-Ch-War Maharashtra (GU170808.1) and the lowest nucleotide homology of CHB-1 isolate found 81.96 per cent with ChiVMV isolate ATIPK Pakistan (KJ472764.1).

PCR based detection of Haunglongbing (Citrus greening) in psyllid vector (*Diaphorina citri*)

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Citrus is the most important fruit crop cultivated after mango and banana in India and among all the diseases infecting citrus, the Haunglongbing (HLB) is the most lethal and dreadful disease. The HLB is caused by *Candidatus liberibacter asiaticus* (*Ca Las*) which is a fastidious, phloem limited vascular bacterium. The early detection of HLB is crucial for management of the disease effectively. A rapid molecular PCR based detection method was developed for quick and reliable detection of HLB from the psyllid vector, *Diaphorina citri*. The DNA from the adult was extracted by DNeasy™ Tissue Kit (Qiagen) method duly following the manufacturer's protocol. For detection of HLB, primers namely O11/O12c & A2/J5 were used as forward and reverse primers, respectively that were specific to the 16S rDNA and β -ribosomal protein gene of the bacterium, respectively. The HLB positive samples yielded an amplicon of 1160 bp (for O11/O12c primers), 703 bp (for A2/J5 primers) and there was no such amplification observed in the HLB negative samples. Using this method, *Ca Las* can be accurately detected in psyllid adults as well as different nymphal instars (third, fourth, fifth) and it is sensitive enough for *Ca Las* detection in a single adult psyllid extract and also from nymphs. This reliable, sensitive detection assay may be useful to understand the vector-pathogen relationship and also for epidemiology in order to initiate timely management practices for HLB disease.

Characterization of *Xanthomonas axonopodis* pv. *betlicola* causing leaf spot in betel vine

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Betel vine (*Piper betle* L.) is an important horticultural crop of aesthetic and commercial values grown for its heart shaped deep green leaves mainly in Asian countries. Among diseases, bacterial leaf spot disease is caused by *Xanthomonas axonopodis* pv. *betlicola* is one of the important disease, which caused a great havoc in recent years. Characteristic symptoms of bacterial leaf spot were noticed during survey and the samples were collected for isolation of pathogen. The colonies appeared on Nutrient Glucose Agar (NGA) medium as circular, convex, yellow to straw yellow with smooth surface and opaque against the transmitted light. The growth of bacteria starts after 24 h and maximum growth was observed at 96 and 144 h after inoculation i.e., stationary phase, after 144 h there was gradual decrease in the growth of the bacterium i.e., decline phase. The *X. a.* pv. *betlicola* liquefied the gelatin, produced the H₂S gas, hydrolysed the starch, positive for KOH test and oxidase test, utilized various carbon sources viz., glucose, sucrose, dextrose and produced mild acid from these carbon sources and failed to utilize the nitrogen source i.e. peptone. Among the varied temperature and pH levels tested for the growth of *X. a.* pv. *betlicola*, temperature of 25°C and pH of 7.0 to 8.0 were found optimum for the good growth of the pathogen.

Development of sap transmission method for Onion (*Allium sativum* L.) infecting *Iris yellow spot virus* (G: Tospovirus; F: Bunyaviridae)

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Tospovirus (*Iris yellow spot virus* =IYSV) infected onion scapes were collected from farmer field (Chikkamagalur region) and extracted the viral sap with 0.05M Potassium phosphate buffer by grinding IYSV infected scapes (leaves) with few drops of antioxidant (â-mercapto ethanol). Further, inoculated the viral sap on 10-12 days old tobacco seedlings (*Nicotiana benthamiana* L) by smearing on the emerging leaves; allowed for 10 minutes and washed with distilled water and kept for observations under glass house conditions. After 20 days of inoculation typical symptoms of tospovirus (IYSV) was observed on tobacco (80% infections) by producing spherical, chlorotic lesions on the leaf lamina. The size of the lesions increases as the age of seedlings advances but there were no symptoms on un-inoculated seedlings. The Electron Microscopic (EM) observations revealed the presence of spherical virus particle. This confirms the mechanical/sap transmission nature of tospovirus (IYSV).

Effect of glucose on uredospore germination of *Uromyces ciceris- arietini*

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Four different concentrations of glucose (0.50, 1.00, 1.50 and 2.00%) were tested to study the uredospore germination at 20pC. Glucose at 1.50 per cent and 2.00 per cent were on par with each other and significantly superior to other concentrations including control (distilled water) at different time interval. Highest spore germination was observed in 2.00 per cent glucose at 20pC (64.66%) followed by 1.50 per cent glucose (62.50%) after 48 h of incubation. Least spore germination was observed at 0.50 per cent glucose (51.99%) followed by distilled water (51.11%) after 48 h of incubation and both remained on par with each other.

Anthracnose: A menace to betel vine

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Anthracnose is a devastating disease affecting betel vine. It affects economic parts causing severe crop loss to the farmers. The symptom starts as small circular black spots initially from the tip of the leaves which later enlarges surrounded with a yellow halo and spreading the entire leaf surface. In severe cases, the disease leads to the complete gridling and death of the vine. A survey conducted in the southern tracts of Kerala revealed heavy incidence of the disease at Thiruvananthapuram and Alappuzha. The disease incidence was severe during rainy season. The pathogen, *Colletotrichum gloeosporioides* was isolated from the disease sample collected from 5 different locations namely Vellayani, Kalliyoor, Kattakada (Thiruvanthapuram district), Kareepra (Kollam dist.) and Cherthala (Alappuzha). The pathogen isolated from different locations were made into pure culture and proved its pathogenicity. The isolates were designated as C1, C2, C3, C4 and C5. The pure cultures of different isolates were used for their morphological studies. The morphological studies revealed that all the isolates had sparse to fluffy growth, greyish white to off white in colour. The isolates were observed for colony reverse in terms of concentric ring and zones formed by acervuli. Most of them had the concentric rings.. The time taken for completing growth in petri dish varied from 7-9 days among the different *Colletotrichum* isolates. The isolate C4 slow grower. The cultures C2, C3 and C5 took minimum period of 7 days for completing an area of 63.585 cm². The average growth rate (cm) ranged from 1.0-1.73 cm varied among different isolates. The conidia were oblong or cylindrical or slightly dumbel, hyaline, aseptate with rounded ends and one to two oil globules. Conidia on the culture media were found to be in orangish mass. The isolates C1 and C2 had orange sporulation in 6,10 days respectively.

Seed health testing techniques for detection and diagnosis of seed-borne infection of bacterial pustule of soybean caused by *Xanthomonas axonopodis* pv. *glycines*

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The identification of bacteria and fungi was done based on the morphological and colony characters. Among the fungi, *R. bataticola* and *C. kikuchii* often appeared in many samples along with species of *Colletotrichum* and *Fusarium*. The colonies of *Xanthomonas axonopodis* pv. *glycines* appeared as circular, convex, yellow to straw yellow with smooth surface and opaque against the transmitted light. The vegetative mycelium of *Rhizoctonia bataticolais* colorless when young but became brown colored as they grew and matured. *Cercospora kikuchii* showed a typical mat of mycelium with a reddish-purple pigment in the medium. The acervuli of *Colletotrichum truncatum* was oval to elongate. *Fusarium* sp. in general, it produced three types of asexual spores: microconidia, macroconidia, and chlamydospores. In component plating technique experiment *Xanthomonas axonopodis* pv. *glycines* was associated only in pericarp region while *R. bataticola* was found in pericarp and endosperm whereas *C. kikuchi* was found in pericarp, endosperm and hilum, *C. truncatum* and *Fusarium* spp. was found in pericarp and hilum. In component plating technique inoculum treated seeds shown symptoms like dark brown pustules.

Effectiveness of different cultural media on the growth and sporulation of *Colletotrichum gloeosporioides* causing anthracnose disease of mango (*Mangifera indica* L.)

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Colletotrichum gloeosporioides causing anthracnose which is a serious postharvest disease in mango accounting for 15-20% loss. The variation in growth and sporulation characteristics of *C. gloeosporioides* on eight different solid media was investigated. The results of the cultural studies on solid media indicated that the radial growth of *C. gloeosporioides* was maximum on potato dextrose agar (88.33 mm) which was significantly superior over all other tested medium followed by Richards's agar (79.50 mm), Asthana and Hawker's 'A' agar (77.42 mm), Sabouraud's agar (74.00 mm), Oat meal agar (71.17 mm), Czapek's agar (68.5 mm) and Malt extract agar (61.00 mm). The least radial growth was recorded on Host leaf extract agar (59.08 mm). Mycelium was whitish in most of the media, except in case of Potato dextrose agar, Asthana and Hawker's 'A' agar and Malt extract agar produced grayish to white mycelium and dirty brown in case of Host leaf extract agar. Sporulation was good in all the media tested, however maximum sporulation was observed in Richard's agar (7.25×10^4 conidia ml⁻¹) followed by Potato dextrose agar (6.72×10^4 conidia ml⁻¹). Asthana and Hawker's 'A' agar (3.90×10^4) and in host leaf extract agar average sporulation (2.62×10^4) was observed.

National certification system for tissue culture plants: An Overview

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The advent of tissue culture/micro propagation technology has made it possible to produce genetically pure planting material to meet the domestic needs as well as international trade. However, the tissue culture propagation, does not exclude the infection of viruses, viroids, Phytoplasma and bacteria unless the parental material used for tissue culture production are tested and maintained free from above mentioned pathogens as well as stock-cultures maintained free from above pathogens. Therefore, National Certification System for Tissue Culture Raised Plants (NCS-TCP) is being implemented by Department of Biotechnology (DBT), Govt. of India since year 2006, as per the Gazette of India Notification under the Seeds Act. 1966. NCS-TCP has been instrumental in building capacities of the tissue culture companies for producing quality planting material and also enhancing their market reach through a certification process. NCS-TCP is unique, dynamic and comprehensive system which is one of its kind in the world. For the successful implementation of NCS-TCP DBT has identified NCS-TCP Management Cell (NMC), Referral Centers (RCs) and Accredited Test Laboratories (ATLs). Tissue culture production facilities get recognition under this quality management system based on compliance with technical capabilities, infrastructure, package of practices and documentation/ record keeping. Once the tissue culture production facility is recognized they become eligible to get their tissue culture raised planting material certified from ATL. The certified batches of tissue culture raised plants are provided with certification labels enabled with barcode. This barcode provide end users to trace back history of plants from where the tissue culture raised planting material are derived. Advisory Services and Updation of Guidelines/ Standard Operating Procedures (SOPs). Monitoring of Recognized TCPFs, ATLs and Referral Centres. Referral Laboratories have been identified for carrying out confirmatory tests, if required, and also for developing standard protocols, maintenance of referral material, training etc. The responsibility of referral laboratory is to carrying out confirmatory tests in the event of dispute or nonconformity of test results. The purpose of this system is to facilitate production of quality planting material through virus diagnosis and genetic fidelity/ uniformity testing and to ensure that the tissue culture raised plants are free from viruses and other fastidious pathogen and also that the tissue culture raised plants are true to the type/ genetically uniform.

Detection and quantification of bacterial blight pathogen *Xanthomonas axonopodis* pv *punicae* in pomegranate using robust molecular approach

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Bacterial blight caused by *Xanthomonas axonopodis* pv *punicae* (Xap) is a devastating disease in pomegranate production resulting in severe yield losses both in terms of quality and quantity. Erratic symptom development of the disease makes it problematic to evaluate disease severity accurately through conventional screening techniques in both under field and greenhouse condition, leading to inconsistent tracking of genotypes over years. In the postgenomic era, it is very crucial to assess the disease severity to estimate the level of resistance precisely. Development of a robust technique for the timely and accurate detection of Xap will be helpful in the active surveillance and management of the disease. In the present study, we have used robust molecular approach, real-time quantitative polymerase chain reaction (qPCR) to detect and quantify Xap biomass in infected leaves of pomegranate genotypes. By using Xap specific primers, we successfully quantified the biomass of pathogen in different genotypes of pomegranate. qPCR is highly sensitive method than conventional PCR for the detection of Xap in pomegranate.

Cultural and morphological characteristics of false smut pathogen (*Ustilaginoidea virens*) isolates from different ecosystems of Karnataka (India) on rice

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False smut disease caused by *Ustilaginoidea virens* (Cooke) (Takahashi) has been recorded in all rice growing countries worldwide. In the present study fifteen isolates of *U. virens* from different ecosystems of Karnataka was isolated and subjected to cultural and morphological investigations, fastest growth was observed on the potato sucrose agar 75.38 mm colony diameter, followed by oat meal agar medium (69.81 mm), among fifteen isolates based on colony colour, isolates exhibited considerable variation. Initially, colony appeared either white, cream and dull white, whereas, after 30 days, colony turned in to white, yellow and green, and three types of growth patterns such as raised, less fluffy and fluffy. All isolates formed chlamydospore on culture media and variability was identified in their size (18.60-104.29 μ m²) shape (Globular, round irregular and ovoid) and colour (light brown, brown and dark brown). Chlamydospores were light brown to brown for of hill isolates and brown to dark brown for isolates from irrigated ecosystem. Isolates from Hyderabad Karnataka region showed smaller chlamydospores (18.60-50.87 μ m²) compared to other isolates (50.87-104.29 μ m²). Isolates from irrigated Bhadra and Hilly ecosystem showed the maximum chlamydospore size (50.87-104.29 μ m²) and corresponding disease severity was also more in those ecosystems (10.73-17.12 %).

Recombinant tomato leaf curl new Delhi virus is associated with yellow vein mosaic of okra in India

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Okra (*Abelmoschus esculentus*) is an important vegetable crop grown extensively in tropical, subtropical and warm temperate zones of the world. India ranks first in the world with a production of 6 million tonnes of okra from over 0.5 million ha area. The crop is susceptible to many diseases from seed germination to harvest. Among the different diseases yellow vein mosaic and enation leaf curl diseases is caused by whitefly transmitted begomoviruses associated with wild and cultivated species of okra is a major constraint for its production in India. Presently none of the cultivated okra genotypes were gave complete resistance to yellow vein mosaic and enation leaf curl diseases and the incidence diseases was ranged from 85 to 100% in different locations of India. Total three hundred twelve okra leaf samples showing diverse kind of symptoms were collected from different locations of India. The PCR mediated amplification detected the presence of begomovirus in all okra samples. 45 out of 312 okra samples are having both DNA-A and DNA-B-like-sequence of Tomato leaf curl New Delhi virus (ToLCNDV) and two hundred sixty seven okra samples possess only DNA-A-like sequence. These results were further confirmed with dot blot hybridization using CP and NSP gene probe of ToLCNDV. On the basis of the determined sequences (1.2kb fragment), the 45 okra samples were associated with a member of a previously described bipartite begomovirus, which is closely related to ToLCNDV (nt sequence identity is > 96% among the isolates). Therefore one isolate was selected from each state for amplification and determining the full-length genomes of begomoviruses (DNA-A and DNA-B). The sequence analysis of DNA-A and DNA-B-like-sequence okra isolates shared a maximum nucleotide (nt) identity of >90% with ToLCNDV infecting tomato, eggplant and potato. A Phylogenetic and recombination analysis indicated that both DNA-A and DNA-B-like-sequence of ToLCNDV infecting okra is recombinant origin from BYVMV, ToLCNDV and SLCCNV as the foremost parents. This is the first report of ToLCNDV is associated with yellow vein mosaic disease of okra in India.

Detection, characterization and *In-silico* analysis of *Candidatus Phytoplasma australasiae* associated with big bud disease of tomato in India

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Tomato (*Solanum lycopersicum* L) is one of the important vegetable crops grown throughout the country under diverse agro climatic conditions. The crop is prone to many fungal, bacterial, phytoplasmal and viral diseases. Among these, big bud disease of tomato caused by phytoplasma is a looming threat in almost all tomato growing states of India. Tomato plants showing witches broom and bushy appearance symptoms were collected from different states of India. The presence of phytoplasma was confirmed by PCR using phytoplasma specific universal primer pairs of 16S rRNA and SecY gene. The amplified PCR product was cloned and sequenced. The complete nucleotide (nt) sequence of 16S rRNA and SecY genes of eight tomato big bud phytoplasmas showed maximum nt identity of 95 to 100% with peanut WB group (16SrII). Further *In-silico* RFLP analysis of 16SrRNA gene of tomato big bud samples showed similarity coefficient in the range of 0.68 to 0.95. Therefore the strains are significantly distinct from other subgroups of pea nut witches broom. Further, the phylogenetic analysis revealed that, they are closely clustered with peanut witches'-broom strains (16Sr II), specifically within the 16Sr II-D and 16Sr II-A subgroups. A comprehensive recombination analysis showed the evidence of both intra and inter-species recombination in tomato big bud isolates with most part of their 16Sr RNA F2nR2 fragments descending from *Ca. P. brasiliense* (16Sr XV) as major parent. Similarly in case of SecY gene, all the big bud isolates are intra-species recombination with major portion descending from *Vinca virens*-[16Sr VI-A] and potato purple top wilt-[16Sr XVIII-B]. The genetic similarities and the potential threat of this new phytoplasma is serious threat to tomato cultivation in India.

Development of standard set of differential cultivars of lentil to determine races/ pathotypes in *Fusarium oxysporum* from India

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The present study was undertaken to characterize *Fusarium oxysporum* f. sp. *Lentis* (Fol) isolates causing wilt in lentil collected from different regions/ states of India. To identify new races, utilized the standard set of differential cultivars. The preliminary screening was carried out on identifying standard set of differential cultivars to determine races/ pathotypes under controlled conditions. From set of 120 accessions, 16 accessions were identified as putative set. Out of 16 accessions, 7 accessions showed atleast one isolate showing differential response to the tested isolates were selected as a standard differential set. Standard set of differentials included seven differential accessions. Virulence pattern was proposed to understand distribution of isolates among of Fol races/ pathotypes. Fourteen virulent isolates from 7 states were classified into 5 different races based on differential response on 7 differential cultivars developed. To determine the genetic diversity, the UPGMA analysis was carried out which grouped the isolates into five major clusters from RAPD and SSR at 18% and 25% genetic similarities respectively. The groups were partially corresponding to the state of origin/lentil growing regions but fully corresponding to the races identified based on 7 differential set of lentil. The differentials and dendrogram clearly revealed that the isolates from each state were highly variable and indicated that the existence of more than one race prevalent in every state.

Morphological characteristics of *Rhizoctonia bataticola* causing dry root rot of chickpea in North-Eastern Karnataka

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Chickpea (*Cicer arietinum* L.) is one of the most important food legumes being cultivated in almost all over the world including temperate and sub-tropical regions. Among the diseases of chickpea, the production of chickpea is largely constrained by many fungal, bacterial and viral diseases. Dry root rot (DRR) caused by *Rhizoctonia bataticola* (Taub.) Butler [Pycnidial stage: *Macrophomina phaseolina* (Tassi) Goid] is a soil and seed borne necrotrophic fungal pathogen that has a global distribution, which can infect more than 284 plant species throughout the world including monocot and dicots. The survey on the dry root rot of chickpea was conducted and collected the 60 isolates from all the surveyed areas. Morphological features of *R. bataticola* was studied, the isolates are grown on the potato dextrose agar (PDA) medium and incubated at temperature of 30°C for 10 days. After the growth of pathogen we observed the mycelial character, sclerotial character, nature of mycelia growth on media. Among the sixty isolates 36 isolates shown dark black colored mycelia and sclerotia, eight isolates shown grey colored mycelia and sclerotial color, 06 isolates shown creamy pistha colored mycelia and four isolates shown centrally whitish rings like growth. In case of growth nature of mycelia some isolates shown fluffy, some are appressed and some are velvety appearance.

Serological detection of sunflower necrosis virus from weed hosts and thrips vector in sunflower ecosystem through DAC-ELISA

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Sunflower (*Helianthus annuus* L.) is an important edible oil seed crop in India. Sunflower necrosis disease (SND) caused by Tobacco streak virus (TSV) is one of the most limiting factors for sunflower cultivation. The virus has a wide host range infecting members of many families. Direct antigen coating-ELISA was employed to determine the presence of Tobacco streak virus in weed hosts and thrips vector in sunflower ecosystem. Among 21 weed hosts tested, eight weed species viz., *Parthenium hysterophorus*, *Euphorbia geniculata*, *Abutilon indicum*, *Malvastrum coromandelianum*, *Acanthospermum hispidum*, *Phyllanthus niruri*, *Stachytarpheta indicum* and *Galinsoga parviflora* were found positive for the presence of TSV. This indicates that, these weed host plants are the potential sources for TSV under field condition. The three species of thrips viz., *Thrips palmi* Karny, *Frankliniella schulzei* Trybom, *Scirtothrips dorsalis* Hood were found on sunflower and collateral weed hosts of TSV. ELISA analysis revealed the presence of TSV in *Thrips palmi*, whereas it was absent in other two *Thrips* species. The results indicated that, *Thrips palmi* as the potential vector for transmission of TSV.

Development and validation of LAMP assay for rapid detection of *Puccinia triticina* causing leaf rust of wheat

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Leaf rust of wheat caused by *Puccinia triticina* has significant impact on wheat production worldwide. Diagnostic tools that allow rapid and efficient pathogen identification are needed to minimise risk and time constraints associated with disease management. In the present study, detection of *Puccinia triticina* has been simplified by developing rapid, reliable, efficient and visual method *i.e.*, Loop mediated isothermal amplification of DNA (LAMP). Based on *in silico* analysis of *P. triticina* genome, PTS68, a simple sequence repeat (non-genic region) was found highly specific to leaf rust fungus. A marker (PtRA₆₈) was developed and its specificity was validated by PCR technique which gave a unique and sharp band of 925bp in *P. triticina* pathotypes only with no amplification observed with DNA of other rust pathogens and non-target fungal pathogens. A novel gene amplification method (LAMP) which enables visual detection of pathogen by naked eye based on change in turbidity in the reaction tube was developed for leaf rust pathogen. A set of six primers were designed from specific region of *P. triticina* and conditions were optimised to complete in 60 minutes at 65°C. A colorimetric detection assay developed in the study could detect presence of *P. triticina* on wheat at 24 hpi (pre-symptomatic stage) which was much earlier than PCR without requiring thermal cycler. Sensitivity of LAMP assay developed in the study was 100fg which was more sensitive than conventional PCR (25 pg) and equivalent to qPCR(100 fg). The developed protocol in the study was utilized for detection of leaf rust infected samples collected from different wheat fields. This colorimetric detection assay indicated colour change from violet to sky blue in positive reaction upon pre-addition of 120 iM hydroxyl naphthol blue (HNB) solution to reaction mixture. Similarly, 0.6 mg EtBr was added to LAMP products, placed on transilluminator to witness full brightness in positive reaction and no such brightness could be seen in negative reaction mixture. Further, LAMP products spread in a ladder like banding pattern in gel electrophoresis. The developed method is efficient, rapid and sensitive for detection of *P. triticina* causing leaf rust of wheat. Our assay is significantly faster than the conventional methods used in the identification of *P. triticina*.

Recent advances in plant pathogen diagnosis in the genomic era

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Infectious plant diseases are caused by pathogenic microorganisms such as fungi, bacteria, viruses, viroids, phytoplasma and nematodes. Plant diseases are responsible for major economic losses in the agricultural industry worldwide. Monitoring plant health and detecting pathogen early are essential to reduce disease spread and facilitate effective management practices. Continuing globalization of trade and the large-scale movement of people and goods have greatly increased opportunities for the introduction of pathogens and pests. The geographic distribution of certain pathogen and pest species influences agricultural trade regulations and affects the international movement of agricultural products. Precision agriculture and plant phenotyping are information and technology based domains with specific demands and challenges for the diagnosis and detection of plant diseases. In order to obtain objective and reliable automated diagnosis and detection of plant diseases, new approaches must be introduced and incorporated into traditional monitoring and rating systems. Accurate estimates of disease incidence, disease severity, and the negative effects of diseases on the quality and quantity of agricultural produce are important for field crop, horticulture, plant breeding, and for improving fungicide efficacy as well as for basic and applied plant research. Reliable and timely assessments of plant disease occurrence and spread are, in particular, the basis for planning targeted plant protection activities in field or greenhouse production and to forecast temporal and spatial disease spread in specific growing regions. Common methods for the diagnosis and detection of plant diseases include visual plant disease estimation by human raters, microscopic evaluation of morphology features, culturing to identify pathogens, serological, as well as molecular diagnostic techniques. Polymerase chain reaction (PCR) and reverse-transcriptase PCR (RT-PCR) has become one of the most commonly-used nucleic acid based methods for the detection of plant pathogens due to its speed, specificity and sensitivity. Some of the disadvantages of PCR/RT-PCR have been avoided by the use of isothermal amplification assays such as loop mediated isothermal amplification (LAMP), recombinase polymerase amplification (RPA), cross-priming amplification (CPA), nucleic acid sequence-based amplification (NASBA), nicking enzyme amplification reaction (NEAR), helicase-dependent amplification (HAD), strand displacement amplification (SDA), rolling circle amplification (RCA) and signal-mediated amplification of RNA technology (SMART) assays, which have been developed for plant pathogens. The benefit of isothermal amplification methods compared to PCR is the constant temperature of amplification. This will result in a high potential for a simple integration in point-of-care devices and a reduction of complexity. Today in the genomics era, DNA and RNA-based molecular assays have become more routine and are gaining a larger share in plant pathogen diagnosis. DNA microarrays and metagenomic next-generation sequencing (mNGS) is an emerging genomic tools to comprehensively detect all pathogens *i. e.* viruses, viroid, bacteria, fungi, and phytoplasma in a single assay. The practical application of each traditional or innovative method depends on the cost and availability of instruments, specialization level (plant, field, farm, or agricultural district), rapidity of analysis, and the stage of disease at which detection is possible.

Cultural and morphological studies on leaf and neck blast isolates of *Magnaporthe grisea* (herbert) barr on rice (*Oryza sativa* L.)

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Rice (*Oryza sativa* L.) is one of the most important cereal crops of the family Poaceae. Presently the rice production is insufficient to cover the needs and hence several countries have been importing rice. *Magnaporthe grisea* causing blast disease on rice. *M. grisea* was grown on four different media and the results pertaining to the cultural characteristics are presented. Among the different media, Oat meal agar and potato dextrose agar was found to be best media for radial growth and sporulation of *M. grisea*. Conidial size varied from in leaf and neck blast isolates, respectively. Oat meal agar media showed off white colour with good and uniform growth, smooth margin and excellent sporulation. The best growth of the pathogen was recorded at optimum pH range from 6.0- 7.0 and temperature of 27°C. The media amended with sucrose and dextrose produced maximum colony diameter. In case of leaf blast, the maximum mean colony diameter was recorded in Oat meal agar (89.16 mm) by potato dextrose agar (74. 63 mm). In case of leaf blast isolate, the maximum sporulation mean index was observed in oat meal agar (3.15) by potato dextrose agar (2.83). In case of neck blast isolate, the maximum sporulation mean index was observed in oat meal agar (3.20) by potato dextrose agar (2.88). In this study oat meal agar showed best media for growth and sporulation of *M. grisea*.

Morphological and molecular characterization emerging fungal diseases of cowpea (*vigna unguiculata*)

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Cowpea is an important legume crop grown in arid and semiarid regions of tropics. India is the largest producer of cowpea among Asian countries. A field survey conducted in many Cowpea growing areas of Karnataka state during 2011-17 showed the occurrence of several fungal diseases responsible for the reduced crop losses. In the present study, the prevalence and incidence of fungal diseases on cowpea were recorded from six major agro-ecological regions of Karnataka. A total of 27 fungal pathogens were recorded in all the six agro-ecological zones. The major diseases include rust (*Uromyces vignae/U. appendiculatus*), anthracnose (*Colletotrichum lindemuthianum*), leaf spot (*Alternaria tenuissima*) and leaf spot of (*P. vexans*), zonate leaf spot (*Dactuliophora* species) respectively. The incidence of each disease varied from one agro-ecological region to another. The identity of fungal pathogens was confirmed by microscopic, morphological and cultural and molecular characteristics. All the major fungal pathogens were tested for their pathogenicity on healthy cowpea (cv.152) in green house conditions. Pathogenicity test revealed the development of typical symptoms after 15-18 days of post inoculation. Fungal isolates of *C. lindemuthianum*, *A. tenuissima*, *S. rolfsii*, *P. vexans* and *Dactuliophora* species were further confirmed by PCR amplification and sequence analysis of internally transcribed spacer rDNA regions. nBLAST sequence search analysis of ITS sequence analysis confirmed the fungal identity of *Phomopsis vexans* (99%), *Diaporthe phaseolarum*, *Alternaria tenuissima* (99%), *A. alternate*, *Colletotrichum lindemuthianum* (99%) and *Sclerotium rolfsii* (99%). ITS sequence of *Dactuliophora* species showed 100% similarity with *Macrophomina phaseolina* suggesting that it might be a sclerotial form of *Macrophomina phaseolina*. Occurrence of various fungal diseases from mild to severe form in this staple legume crop indicates the need for continuous surveillance for the plant diseases is of at most importance for the prevention of fungal diseases under changed climatic conditions.

Prof. M. J. NARASIMHAN
ACADEMIC MERIT AWARD
Competition Session

Antioxidant-mediated survival strategy in primed ragi plants against blast disease

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Ragi blast caused by *Magnaporthe grisea* (Hebert) Barr. is a very severe disease with a subsequent annual loss of ~ 80% yield. It is highly virulent with a wide host range (rice, wheat, rye, barley, pearl millet). Many strategies have been used to manage the disease, of which, use of beneficial, soil microbes is an eco-friendly approach for induced systemic resistance (ISR). It is the state of the plant wherein the selected rhizobacterial strains enhance the ability of the plant to mobilize infection-induced cellular defense responses against the pathogen (priming). The synergism between the plant and rhizobacteria plays a crucial role in host-specific disease resistance by many of those mechanisms or signals. Inoculation of bacteria that protect plants through different mechanisms in pathogen-challenged plants, contributes to the increase in knowledge on plant-microbe interactions. Antioxidants act as signal molecules which subsequently enhances cellular patterns of the host, thus increasing resistance during the early hours of pathogen entry. The goals of the present study were (i) to analyse the performance of rhizobacteria for growth promotion and induce disease resistance under green-house conditions in ragi plants and (ii) to analyse the enhancement of disease resistance by measuring the antioxidant levels at different time (0, 6, 12, 24, 36, 48, 72, 96 hours post inoculation) intervals. Isolated rhizobacteria were identified as fluorescent *Pseudomonas* by partial 16sRNA sequencing. Two isolates, JUPC113 (GenBank ID. KX010601) and JUPW121 (GenBank ID. KX010602) were used in priming the ragi (Indaf 9) seeds. Plants challenge-inoculated with *M. grisea* spores (5×10^4 spores.mL⁻¹) showed reduced disease incidence in plants from primed-seeds, compared to the control. JUPC121 (92.03 ± 0.04%) showed enhanced disease protection rate with vigour index of 3064.00 ± 3.06, disease incidence was highest in control (2.67 ± 0.3) plants and vigour index of (2005.33 ± 3.71). Primed and control samples were analysed for various antioxidants, which showed increase in activities of superoxide dismutase (SOD), ascorbate peroxidase (APX), peroxidase (POD), glutathione reductase (GR), catalase (CAT). A decrease in malanoldialdehyde (MDA) and proline content was observed in plants from primed seeds, which was comparatively significant. The native PAGE showed alterations in the intensity of the isozyme bands in control plants. From these studies, the xymogram and enzymatic assays indicates the induction of disease resistance, thereby sinking the disease severity. Hence the microsymbiont, reinforce the disease resistance and protect the primed plants from *M. grisea* against the detrimental effect, a useful strategy for ragi production by sustainable agriculture.

Isolation, characterization and evaluation of fungal endophytes as potential biocontrol agents on *Sclerotium rolfsii* sacc. infecting *Capsicum annuum* L.

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Increased usage of plant protection chemicals in the management of plant diseases lead to the development of resistance strains among pathogens, environmental pollution and finally fall in benefit-cost ratio due to increased cost of cultivation. To combat these issues, evaluation of biocontrol agents against soil borne pathogen *Sclerotium* sp. infecting chilli was carried out using hidden world organisms called fungal endophytes. Fungal endophytes are living microorganisms present inside the plant tissues imparting tolerance against abiotic and biotic stress, in turn getting food and livelihood from plants. Exploration of fungal endophytes as potential biocontrol agents against *Sclerotium* sp. infecting chilli was made by conducting *in-vitro* studies. Fungal endophytes isolated from selected plants with antimicrobial activity viz., *Hibiscus rosa sinensis*, *Phyllanthus acidus*, *Catharanthus roseus*, *Phyllanthus amarus*, *Solanum torvum*. Total 66 fungal endophytes were obtained from 165 processed tissue segments, morphologically categorised into 25 Operational Taxonomic Units (OTU's) and evaluated against *Sclerotium* sp infecting chilli by dual culture technique. Out of 25 OTU's, 5 OTU's showed greater than 50 per cent and 20 OTU's showed 1-50 per cent inhibition. Endophytic OTU HI2 from *H. rosa sinensis* showed highest per cent inhibition (65%) of *Sclerotium* sp. was taken for further studies. Molecular characterization of *Sclerotium* sp. infecting chilli and endophytic OTU HI2 by amplifying Internal transcribed spacer (ITS) region (ITS1 and ITS4 primers) revealed *Sclerotium* isolate as *Sclerotium rolfsii* and OTU HI2 as *Trichoderma asperellum*. To decipher the mechanism involved in inhibition of *S. rolfsii* by *T. asperellum* broth culture study and double plate assay for diffusible and volatile metabolites were conducted. The metabolite profile of high pressure liquid chromatography (HPLC) analysis showed that the metabolite content of the endophyte was eluted between 21-39 min retention time. Major peaks were observed between 21 to 25 min and 36 to 39 min retention time. In case of pathogen the metabolite peak was eluted at 24 min of retention time. Few metabolite peaks observed individually for pathogen and endophyte were absent in the samples processed from interaction between pathogen and endophyte. However, two peaks were obtained at 37.5 and 39.4 min retention time, which were not observed in the samples with pathogen or endophyte alone. In double plate assay the volatile organic compounds (VOC's) generated by the endophyte inhibited the mycelial growth of pathogen (56.46 %) significantly over control. Analysis of antimicrobial VOC's produced by *T. asperellum* by Gas Chromatography-Mass Spectrometry showed varied peaks. Total thirty-four VOCs were obtained from the potato dextrose agar media (control), endophyte, pathogen and interaction (endophyte and pathogen) in double Petri dish assay treatments. Fourteen tentative VOC's are specific to *T. asperellum* and four VOC's specific to *T. asperellum* and *Sclerotium rolfsii* interaction were detected (Epizonarene, Guaiol, á-Eudesmol and Verticilla-4(20), 7, 11-triene). In host colonization assay *T. asperellum* successfully colonized in chilli stem and root tissues.

Effect of plant growth regulators and signal molecules on patho-physiological functions and their defense responses against bacterial blight of pomegranate

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Different phytohormones and signal molecules like auxins, gibberellins, paclobutrazol, ethylene, salicylic acid, chitosan and nitric oxide were studied to know their effect on growth, flowering, yield and quality attributes and their defense responses against bacterial blight of pomegranate at Division of Fruit Science, University of Horticultural Sciences, Bagalkot during 2015 and 2016. Among these treatments, foliar spray of GA₃ at 50 ppm resulted in enhancing vegetative growth like plant height (2.24 m), plant spread (N-S-2.88 m, E-W-3.05 m) and plant canopy (10.49 m³), whereas, foliar spray of ethrel at 200 ppm enhanced early flowering and helped in inducing highest per cent of hermaphrodite flowers (91.18), with increased fruit setting (72.20%) and maximum yield (16.34 t/ha) in both seasons. Foliar application of ethylene at 200 ppm observed significant reduction in disease incidence on both leaves (4.87%), fruits (2.05%) and twigs of pomegranate plants (0%) followed by paclobutrazol and salicylic acid treatment. Quality attributes like total phenols, anthocyanin content, TSS, reducing and total sugars were also found significantly higher in ethrel treatment followed by GA₃ and paclobutrazol treatment. Enzyme assay and gene expression studies of PR proteins and defense related genes were analyzed to understand the defense mechanism involved during host-pathogen interaction under greenhouse condition. Accordingly, foliar application of salicylic acid, paclobutrazol, ethephon and 2,4-dichlorophenoxyacetic acid (2,4-D) reduced disease incidence to 10.12%, 13.25% and 14.50% respectively compared to control (42.02%). Treatment with PGR was found to increase the activities of defense enzymes such as peroxidase (POD), polyphenol oxidase (PPO), chitinase and phenylalanine ammonia-lyase (PAL) at 0, 3, 6, 12, 24, 48, 72 and 96 hours of post inoculation (hpi). Expression of pathogenesis related genes, PR1, PR3, PR4 and defense related genes, phenylalanine ammonia-lyase (PAL), catalase and callose synthase-3 (CS-3) were found higher in 2,4-D, paclobutrazol, salicylic acid and ethrel treatment respectively. Thus, phytohormone mediated plant defense responses and understanding its biochemical and molecular basis of plant-pathogen interaction enabled to develop effective strategies towards managing bacterial blight, a devastating disease of pomegranate.

Molecular detection of Huanglongbing (citrus greening) disease in Sweet Orange (*Citrus sinensis*) and screening of citrus germplasm in Andhra Pradesh

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Huanglongbing (HLB), previously known as citrus greening disease is one of the most destructive diseases of citrus and responsible for the decline of citrus orchards in Andhra Pradesh and other citrus growing areas in the country. It is a serious threat to the citrus industry worldwide. HLB is a systemic, infectious disease and the bacterium *Candidatus Liberibacter asiaticus* (Las) resides in phloem, transmitted by Asiatic citrus psyllid, *Diaphorina citri*. In this study a roving survey was conducted to estimate citrus greening disease (CGD) incidence under field conditions in three districts of Andhra Pradesh. The disease incidence was ranged from 34.27 to 51.12 per cent, highest being observed in Ananthapuram district and lowest in Prakasham district. Symptoms like yellowing, green islands, upright twigs, mixed symptoms with citrus yellow mosaic virus (CYMV) were observed. Huanglongbing (HLB) PCR primer set HLB forward and HLB reverse were used to amplify the citrus greening disease from infected samples and successfully yielded a 451bp PCR product. PCR product was cloned in pGEM-T plasmid vector and subsequently sequenced. The sequence similarity and BLASTn analysis showed 100 per cent homology with the Asiaticus species. A sensitive and reliable diagnostic protocol for citrus greening disease by real time PCR was successfully standardized by using SYBR Green and TaqMan probe methods with the PCR efficiency of 98 per cent and 91 per cent, respectively. Both methods successfully detected the samples ranging from 10^8 to 10^4 CN/ μ l for SYBR Green methods and 10^5 to 10^1 CN/ μ l for Taqman probe, and quantified the Ct values ranging from 8-21 and 22-32, respectively. Among the 56 citrus germplasm screened against HLB, some genotypes like Mediterranean sweet orange, willow leaf, cala mandarin, sour dig, troyer citrange, rangpur lemon, sunkokan, *Citrus hystrix*, kukudai, CRH-47, Kitchili, gajanimma showed positive to PCR and qPCR even though they didn't show symptoms. Further, the genotypes, pummelo, sour orange and *C. depressa*, *C. hystrix*, *C. moi*, *Fortunella* spp., *C. medica*, *C. madaraspatana*, *C. limettioides*, *C. macrophylla* and Citron showed negative to HLB.

***Trichoderma viride* in combination with cow manure amendment for the management of sunflower charcoal rot**

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The potential of *Trichoderma viride* in combination with cow manure soil amendment for the management of sunflower (*Helianthus annuus* L.) charcoal rot caused by *Macrophomina phaseolina* was evaluated for under pot and field conditions. *Trichoderma viride* strain AU-6 inhibited the mycelial growth of *M. phaseolina* *in vitro*. Sunflower seeds when treated with talc-based powder formulation of *T. viride* strain AU-6 showed significant increases in per cent germination, root length, shoot length and seedling vigour in the standard roll towel method. Treatments consisted of combination of *T. viride* strain AU-6 with cow manure soil amendment at 0.5, 1 and 2 t/ha. Soil application of combination of *T. viride* with cow manure significantly reduced the incidence of charcoal rot and increased the germination percentage and plant height, compared to the experimental controls. Seed and soil application of the powder formulation of *T. viride* strain AU-6 alone was effective in controlling charcoal rot disease; but the combined soil application of *T. viride* strain AU-6 with cow manure increased the efficacy. Organic amendment at the higher rate further stimulated *T. viride* populations, enhanced microbial activity against *M. phaseolina* in the soil and reduced pathogen populations. Higher accumulation of total phenols, PO, PPO, PAL, β -1, 3-glucanase and chitinase activities was observed in combined soil application of *T. viride* with cow manure amended plants challenge inoculation with pathogen. *Trichoderma* is capable of colonizing manure and therefore application of colonized manure to the soil is more appropriate and beneficial. This is the most effective method of application of *Trichoderma* particularly for the management of soil-borne diseases.

Technical Session IV

Epidemiology and disease forecasting

Studies on pathogenicity of root-knot nematode *Meloidogyne incognita* on turmeric

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Turmeric is one of the important spice crops grown in India since the times immemorial. It is used as condiment, dye, drug and cosmetic in addition to its use in religious ceremonies. India is a leading producer and exporter of turmeric in the world. Root-knot nematode (*Meloidogyne* spp.) is one of the major problem, which causes galls/knots in the rhizomes and causes considerable yield losses. A pot study was conducted to assess the pathogenicity of *Meloidogyne incognita* on turmeric at different inoculum densities (0, 10, 100, 1000, 5000 and 10000 J₂ per pot). The progressive reduction in growth and yield parameters with the increasing inoculum levels of *M. Incognita* was observed. However, plant height of 44.33 cm was recorded in plants inoculated with 10000 J₂ per pot as against maximum of 69.67 cm in plants inoculated with 10 J₂ per plant. The least rhizome fresh weight (181.00 g) and dry weight (35.67 g) was recorded in plants inoculated with 10000 J₂ per pot. The soil nematode was highest in plants inoculated with 5000 J₂ per pot (3610) followed by 10000 J₂ per pot (2660) and least in pots inoculated with 10 J₂ per pot (95.33). The highest number of galls per plant was observed in plants inoculated with 10000 J₂ per pot (107.33) followed by 5000 J₂ per pot (101.33). Reduction in growth and yield parameters and increase in number of galls was observed with increase in inoculum levels of *M. incognita*.

Survey for the diseases of banana in Northern Karnataka

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A random survey was conducted to know the disease scenario in banana cvs. Grand Naine, Rajapuri and Ney poovan in Belagavi, Bagalkot and Gadag districts of northern Karnataka during 2016-17. The results showed that no new and emerging diseases were recorded during the survey. Among the different diseases recorded, the *Eumusae* leaf spot disease intensity was highest (45.45%) in Munavalli area of Belagavi district. The range was 5.56 to 45.45 per cent. Incidence of Freckle leaf spot ranged from 3.00 to 5.80 per cent. Banana Bract Mosaic Virus (BBMV) was 3.0 to 4.50 per cent and bacterial rhizome rot was from 6.00-10.60 per cent. The Results also indicated that there was no minor disease resulted with major problems. The *Eumusae* leaf spot was highest in Munavalli area may be due to maintenance of more number of suckers per plant (4-5 nos), closer spacing, susceptible variety Rajapuri and more number of ratoons (5-8 No.s).

Status on bacterial leaf spot of tomato and pepper caused by *Xanthomonas* spp. in India

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Bacterial leaf spot (BLS) caused by *Xanthomonas* species is one of the devastating diseases in tomato (*Solanum lycopersicum* L.) and pepper (*Capsicum annuum* L.) leading to losses up to 23–44%. BLS infected samples of tomato, hot pepper (Chilli and bell pepper were collected from 5 different states of India viz., Himachal Pradesh, Karnataka, Uttarakhand, Tamil Nadu and Haryana. Disease symptoms on tomato and capsicum appear on all most aerial parts: leaves, and fruits, petioles. Leaves show initially water-soaked, angular lesions, which later become brown and necrotic and lesions may coalesce into foliar blights. On fruits, lesions are initially tiny, blister-like spots, and are frequently raised. On the basis of DNA homology, four species of *Xanthomonas* i.e. *X. vesicatoria*, *X. gardneri*, *X. euvesicatoria*, *X. perforans* have been identified. For characterization of these morphological, physiological, biochemical, pathogenicity and PCR based molecular techniques were used. Among these species, *X. euvesicatoria* is dominated and it was confirmed by using specific different set of primers like Bs-XeF & Bs- XeR and Xeu 2.4 & Xeu 2.5 and all the isolates were amplified at 173bp and 208 bp respectively. Out of 11 races of *Xanthomonas* reported from different countries of the world, 5 races such as race 0, race 1, race 3, race 4 and race 6 based on susceptible and hypersensitive reaction (HR) on pepper differentials such as ECW (Ealry Cal Wonder), ECW 10R, ECW 20R, ECW 30R and PI235047 were identified from India. Among them, race 6 was found to be dominated followed by race 1 across the country. Genetic diversity of these 31 isolates of *X. euvesicatoria* along with four out group *P. fluorescence* DTPF-3, *X. campestris* pv. *cmpestris* Xcc-4, and Xcc-C23 and *B. subtilis* DTBS-5 was done by REP, ERIC and BOX-PCRs fingerprinting. High level of genetic diversity among the *X. euvasicatoria* isolates was observed.

Status of sapota diseases in northern Karnataka

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The roving survey was conducted in Belagavi, Bagalkot and Gadag districts of northern Karnataka to record the disease scenario in sapota during 2016-17. The results indicated that no new and emerging diseases were recorded. Among the diseases recorded, the leaf spot, *Phaephleospora indica* was the major disease with the range from 8.55 to 40.36 per cent. The Highest PDI of 40.36 per cent was recorded in Mustigeri of Belagavi district followed by Gokak (35.63) and Hidkal dam of Belagavi district (33.75). The other diseases recorded include Fascination, Sooty mold and Phenarogamic parasite from 0-8 per cent. The Fixed plot survey was also conducted on the PDI of *Phaephleospora* leaf spot at ICAR-AICRP on fruits research plots in the cultivars Kalipatti and DHS-2 during I & II week of every month from April-2016 to March -2017. The results indicated that *Phaephleospora* leaf spot disease intensity was maximum in DHS-2 (29.66%) and Kalipatti (26.24%) during III week of October, 2016 and minimum of 0.40 and 0.41 per cent in Kalipatti and DHS-2 varieties respectively during April-III week.

Development of forewarning system for yellow mosaic disease in mungbean

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Yellow mosaic disease caused by Mungbean Yellow Mosaic Virus (MYMV) is considered as a number one threat of mungbean, limiting its production and productivity. The virus is transmitted by whitefly (*Bemisia tabaci* Genn.). The current study aims to study correlation between whitefly population, yellow mosaic incidence with weather parameters during *kharif* 2016 at two locations viz., Kavalur and UAS, Raichur campus of Koppal and Raichur districts respectively. The findings revealed that, highest whitefly population observed induring 26th SMW at Kavalur and 29th SMW at Raichur campus during cropping period. Correlation analysis revealed showed that, there was positive significant relation existed between whitefly population and maximum temperature at both the locations Kavalur and Raichur ($r= 0.079$ and $r=0.572$ respectively). Negative correlation was found between minimum temperature and rainfall at Raichur ($r= 0.146$ and $r= 0.684$ respectively.) only with minimum temperature at Kavalur ($r= 0.889$). Non significant positive relation was observed with whitefly population and relative humidity at both the locations. While disease incidence was negatively correlated with maximum temperature at both Kavalur and Raichur ($r= 0.737$ and $r= 0.707$ respectively). Disease incidence was positive but non significant with relative humidity and wind speed at Raichur, wind speed was significant at Kavalur. Correlation between whitefly population and disease incidence was positively related with each other at both locations. The regression analysis showed that weather parameters contributes towards whitefly population and disease incidence build up and it was 98.3 per cent ($R^2= 0.983$) at Kavalur and 97.8 per cent ($R^2= 0.978$) at Raichur. The findings of the experiment also gave a suitable Which also provided multiple regression equations at both locations to know the forewarning prediction models for yellow mosaic incidence in mungbean. The prediction of whitefly outbreak found in the study shall be adopted for management of yellow mosaic disease in mungbean.

Vector influenced seasonal variation in sunflower leaf curl disease

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Sunflower an oilseed crop is often fluctuating in its area, production and productivity, the declining trend in the past decade is a major concern of policy makers and scientists due to various reasons and stresses. The diseases are equally responsible for reduced production and productivity discouraging growers. The vector borne virus diseases of sunflower remains undeterred, especially the recent leaf curl disease which is transmitted by whitefly *Bemisia tabaci*. The current study focuses on seasonal variation in leaf curl disease of *Tomato leaf curl karnataka virus*. Since, sunflower is now a days being cultivated throughout the year has crossed seasonal barrier in farmers field. However, the leaf curl disease was found still confined to *rabi* season. This seasonal selectivity was under surprise of growers and scientists both. The field surveys conducted during *rabi* and *kharif* both in 2015-16 and 2016-17 over two years also revealed its occurrence in field during *rabi* season. The seasonal selectivity was found mainly due to abundant vector population during *rabi* than *kharif*. The whitefly vector population was monitored throughout the year and found maximum during December to April which is the main reason for spread of the disease during *rabi*. Although whitefly population was noticed during *kharif* but intermittent rains and lower temperature disturbed their growth and multiplication restricting spread of virus. Though October to December was drier but lower temperatures did not support multiplication of whitefly and also vector takes more time to complete its life cycle during winter than drier/summer season. Findings of this study directs towards making choice of season and plant protection measures to be undertaken for disease free cultivation of sunflower and management of the disease respectively.

Status of diseases in redgram and pumpkin intercropping system in *kharif*

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The pumpkin and redgram intercropping system was introduced in *Kharif* season under National Innovation in Climate Resilient Agriculture (NICRA) Project at Kalaburgi. Objectives of the studies included production potentiality, economic feasibility and disease incidence under intercropping of pumpkin and red gram in 1:1 row ratio. The status of diseases in intercropping system was studied during 2016-17. During the season 28 days rain gap during crop pod initiation stage shown epidemics of *Fusarium* incidence. Conservation farming recorded lower disease incidence in both the crops. In pumpkin, *Fusarium* wilt and downy mildew incidence recorded were 4.3 and 3.2 per cent, respectively with yield of 11.5 t/ha, compared to farmers practices which recorded wilt and downy mildew incidence of 14.8 and 11.4 per cent, respectively with yield of 7.2 t/ha. The wilt of pigeonpea was reduced by 32.8 per cent with higher grain yield compared to farmers practice. The interspecies competition of pumpkin was very pronounced in intercropping with redgram. The average fruit yield and reduction of diseases of pumpkin were higher compared to conventional farming. Although intercropping resulted in lower yields than that of sole crop was better compensated by components crops in terms of total yield and income.

Status of pest and diseases in major seasonal crops of Kalaburagi district

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Kalaburagi is popularly called as “pulse bowl of Karnataka”, it contributes 61 per cent share in total production of red gram at state level. Rapid row survey was undertaken during cropping season of 2015 and 2016 to find out the threats and constraints in increasing productivity in crops of pulse growing area and to get the clear picture of pest and disease scenario in Kalaburagi district of Karnataka. The pest and disease incidence and scenario on these crops were recorded during the weekly field visits. The survey work carried out in Alanda, Chincholi, Afzalpur, Chittapur, Sedam, Gulbarga, Jewargi taluks. The surveyed data revealed that, higher incidence of pigeonpea dry root rot (18.0 %) noticed in Jewargi followed by Gulbarga (15.5 %) taluk. The incidence of *Phytophthora* wilt (17.2 %) was more in Sedam followed by stem canker (11.0 %) in Chittapur taluk. The highest incidence (10.5 %) of flower dropping and cercospora leaf spot noticed in Chincholi taluk in late *kharif* seasons. The sterility mosaic disease incidence is more in Chincholi (11.0 %) followed by Chittapur (7.2 %) taluk. In Alanda taluk, 19.0 per cent incidence of severe moisture stress, drying and wilt was noticed. During the survey it is noticed in few villages that, the drought affected branching system, flower setting and pod setting of the crops. Also noticed the lack of moisture resulted in soil cracking along with termite attack in chickpea fields of Gulbarga (8.2 %) and Alanda taluks (6.3 %). The more incidence of cotton leaf reddening (23.0 %) was noticed in Jewargi and Gulbarga taluk. Due to low soil moisture the lanky growth of jowar M-35 was noticed in Alanda and Afzalpur Taluks in late *rabi* seasons.

Incidence of major soil borne diseases of groundnut in north eastern Karnataka

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Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed crops in the world. In India, it is cultivated over an area of 5.31 million hectares with the production of 6.93 million tonnes. Groundnut is known to be affected by a variety of stresses from planting to storage. Different diseases hamper the groundnut production. They are caused by fungi, bacteria, viruses and nematodes. Among these, soil borne fungal pathogens causing serious losses have prime importance. A roving survey was conducted during *kharif* and *rabi* 2016-17 in different groundnut growing areas of north eastern Karnataka to assess the status of incidence of soil borne diseases of groundnut and to collect diseased samples infected by *Rhizoctonia bataticola* under field condition. Maximum collar rot (13.40 %) was observed in Koppal taluk and the least (11.00 %) in Lingasgur taluk of Raichur district. Maximum stem rot incidence (21.20 %) was observed in Deodurga taluk of Raichur district and the least incidence (17.60 %) was observed in Kustagi taluk of Koppal district. Dry root rot incidence was highest (28.00 %) in Koppal taluk of Koppal district and the least was recorded (21.00 %) in Deodurga taluk of Raichur district.

Survey for the incidence of major diseases of papaya in Mandya and Mysuru districts

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Papaya (*Carica papaya* L.) is the important fruit crop believed to be native of southern Mexico and neighboring central America. It is grown in tropical and subtropical countries all over the world. India is the largest producer of papaya in the world. Production of papaya is affected by many biotic and abiotic stresses. Among the foliar diseases, papaya ring spot virus, papaya leaf curl and black spot of papaya are considered as major constraints for the production of papaya. To assess the impact, the roving survey was carried out during 2016-17 to record the incidence of major diseases of Papaya namely black spot of papaya caused by *Asperisporium caricae* and papaya ring spot disease at KR Nagara, Hunsur and Mysuru taluks of Mysore district and Srirangapatna, Mandya and Malvalli taluks of Mandya districts at both vegetative stage and fruiting stage. In Mandya district among the different taluks surveyed, the highest incidence PRSV was recorded at Srirangapatna taluk, which has recorded 89.72 % followed by Mandya taluk (83.05%). The highest black spot incidence was noticed at Mandya taluk (55.00 PDI). In Mysuru district the maximum incidence of PRSV (89.28) was recorded at Hunsuru taluk followed by 43.74 % in Mysuru taluk. The maximum black spot incidence 55.56 PDI was recorded at Hunsur followed by Mysuru, which has recorded 50.00 PDI and least intensity of 40.74 PDI was recorded at KR Nagara taluk. In general the incidence of PRSV was more during fruiting / harvesting stage compare to vegetative stage of the crop.

Epidemiology and loss assessment of chilli veinal mosaic virus causing mosaic in capsicum (*Capsicum annuum* var. *grossum* Sendt)

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The survey was conducted during *rabi* 2015-16 to determine the incidence of mosaic disease of capsicum in major capsicum growing districts namely, Chikkaballapura, Kolar, Bengaluru rural and Ramanagar. The per cent incidence of mosaic disease based on symptoms in field was noticed, highest was in Ramanagar (54.85 %) and the least incidence of mosaic disease was observed in Chikkaballapura (26.85 %). Transmission and host range studies under glasshouse conditions revealed that ChiVMV is transmitted mechanically. Among 16 host plants tested, 7 plant species (*Nicotiana tabacum* cv. Samsun, *Nicotiana glutinosa*, *Nicotiana occidentalis*, *Datura metel*, *Physalis floridana*, *Solanum nigrum*, *Capsicum annuum*) were infected with the Chilli veinal mottle virus disease and the symptom could be seen in (20-25) days. The per cent transmission of ChiMV by aphid (*Aphis gossypii*) was used. The results showed that ChiVMV can be transmitted by *Aphis gossypii*. However, five aphids per plant showed highest per cent transmission (100 %). The effect of different dates of inoculation on different plant growth parameters, revealed that the highest per cent disease transmission was observed in Inoculation 15 days after sowing (100.00 per cent) with 100 per cent loss and lowest transmission of 44.66 per cent with only 6.06 fruits per plant.

Pathogenesis of *Puccinia* species on barberry plants established at Wellington

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Barberry species collected from southern hills (Nilgiris and Kodaikanal) were evaluated for their establishment under field conditions. Seedling plants raised from true seeds were successful and established well as compared to plants transplanted through vegetative propagation. Pathogenesis of *Puccinia* species were carried out from seedling plants to adult plant stages even up to flowering and fruits set. Out of all growth stages, immature leaves were mainly observed with aecia, uredia and telia stages of *Puccinia* species. Different maturity stages were also recorded among the spores of test genera. Majority of the mature leaves were colonized with telia and teliospores. Teliopores were highly pigmented. However, basidia and basidiospores were not detected in any of the leaf samples of *Barberry* species associated with rust pathogen. Large number of grass species was also observed with uredia and urediospores of *Puccinia* in the same Barberry field. Formation of aecial cups and urediospores was more frequent between February to end of March months. Light and advanced microscopic analysis (compound and scanning electron microscopy) confirmed the identity of the rust spores from newly established Barberry plants. Further works are in progress to establish their relationship with pathogenesis on wheat and allied crop rusts with required precautionary measures.

Status of arecanut diseases in southern transition zone of Karnataka

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Arecanut (*Areca catechu* L.) plantation spread across 2.27 lakh hectares in Karnataka predominantly grown in humid tropics of India. Productivity of the palm is affected by a number of diseases and nutritional disorders. In southern transition zone of Karnataka, arecanut is grown as major crop or as a major component in multi-storey cropping system. Areca palm is prone to a number of diseases during its different stages of development. Forty fungal species, a bacterium and an algae parasite are associated with areca palm causing varying degrees of damages to the palms have been discovered and identified. The other most deadly disease is fruit rot commonly called as Mahali/Koleroga caused by *Phytophthora arecae* is one of the major diseases of arecanut. This occurs as an epidemic in the heavy rainfall areas of Karnataka. Heavy incessant rain, cloudy weather conditions since the beginning of June till July end to September in six districts of Malnad and coastal Karnataka viz., Shivamogga, Chikkamagaluru, Uttarkannada, Dakashina kannada, Kodagu, Davanagere and Chitrdurga has dealt a serious blow to farmers, particularly arecanut growers who have lost considerable quantity of their crop up to 60 to 70 per cent during 2016. Yellow leaf disease, a dreaded disease suspected to be caused by phytoplasma, also causes losses to its crop about 50- 100 per cent which is rampant in Shringeri and Koppa taluks of Chikkamagaluru district of Karnataka. Yellowing of leaves begin in the inner whorl, gradually spreading to the outer parts of the crown. Association of *Phytoplasma* with the disease has been confirmed. Acid soils besides water logging conditions are predisposing factors in the incidence of the disease. Lack of balance nutrition and unscientific cultivation practices make the palm susceptible to the disease. Bud rot is a fatal disease of areca palms caused by *Phytophthora palmivora* and characterized by rotting of terminal bud and surrounding tissues and ultimately killing the palm. Crown rot is also associated in valleys (> 5 %) Even though it affects the palms of all ages, young palms in low lying and moist situations are more susceptible to the disease. It is generally a sporadic disease, but some times appear in epidemics forms. The disease commonly occurs in hilly areas, West and East Coasts of Karnataka. Bud rot disease incidence on arecanut recorded up to 15% in Karnataka. In southern transition zone of Karnataka the most common disease is Anabe or foot rot, *Ganoderma lucidum* is more prevalent in neglected gardens, causing 7% losses. Button shedding followed by die-back of inflorescence is a severe problem in arecanut plantations. This is primarily caused by *Colletotrichum gloeosporioides* seen during Feb - May months. Bacterial leaf stripe, *Xanthomonas campestris* pv. *arecae* causing water-soaked linear lesions parallel to the midrib of the leaflets. The entire leaflet in a frond may be affected resulting in complete or partial blighting. In severe cases, entire crown may be affected. When growing buds are affected, death of palm takes place. The disease is aggressive during monsoon. Younger palms (3-5 years old) are highly susceptible. Stem bleeding, *Thielaviopsis paradoxa*, it is prevalent in isolated pockets in all arecanut growing region. Younger and middle-aged palms are more susceptible. The disease is serious in gardens with poor drainage. Nut-splitting, Sun-scorching or stem-breaking and Band or Hidimundige are physiological disorder than a pathological problem of universal occurrence in non-traditional areas.

The strategy for disease management included adopting recommended management practices; removal of diseased palms to prevent spread of the disease; identifying disease tolerant palms and utilizing in hybridization programmes. Unlike other agricultural crops areca is to be maintained properly to enjoy the benefits of better yielding it has to be protected at all the stages before during and after harvest from the natural calamities, animals, theft etc. Application of 1% Bordeaux mixture, application of agricultural lime at 200 kg/acre to neutralize soil before on set of monsoon, removal of fallen nuts, provision of drainage, cutting of excessive branches of inter crops like black pepper, cocoa, clove, nutmeg, cardamom, cinnamon and branches of forest trees around arecanut gardens for proper aeration gives the better management of arecanut diseases.

Survey to assess the *Alternaria* leaf spot severity on cabbage in northern parts of Karnataka

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Cabbage (*Brassica oleracea* var. *capitata* L.) is an important vegetable crop of the world. *Alternaria* leaf spot of cabbage (*A. brassicae* and *A. brassicicola*) is one of the major fungal foliar diseases of cabbage. *Alternaria* leaf spot is one of the most widely present next to the black rot of cabbage in northern Karnataka. Hence, roving survey was undertaken during *kharif* 2014 to estimate the severity of *Alternaria* leaf spot of cabbage in major cabbage growing districts of northern parts of Karnataka viz., Dharwad, Haveri and Belagavi. Incidence of *Alternaria* leaf spot of cabbage was almost equally similar in both Haveri and Belagavi districts and disease severity ranged from 27.18 to 55.01 per cent in Haveri and 31.91 to 47.64 per cent in Belagavi districts and 24.98 per cent to 51.53 per cent in Dharwad district. The highest severity of *Alternaria* leaf spot was noticed in fields of Byadgi (55.01%) and least severity was observed in Aralihond village (24.98 %) of Dharwad district. Among the talukas surveyed, maximum mean PDI was recorded in Belagavi taluk (43.91%) of Belagavi district and least severity was observed in Kalagatagi taluk (28.95 %) of Dharwad district. The highest district average disease severity was recorded in Belagavi (40.38 %) followed by Haveri (39.46 %).

Effect of different temperature levels on uredospore germination of *Uromyces ciceris-arietini*

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Temperature is one of the important factor for all metabolic activities of the fungus. Therefore, the effect of different temperature levels on germination of uredospore was studied. Maximum uredospore germination was observed at 20°C at all time intervals, was significantly superior to all other temperature levels, followed by 15 and 25°C. The maximum (89.91%) spore germination of *U. ciceris-arietini* was observed at 20°C followed by 81.01% at 15°C after 48 h of incubation. There was increase in germination with respect to incubation period and temperature up to certain limit. The least spore germination (9.83%) was observed at 40°C followed by 35°C (27.22%) after 48 h of incubation. There was no spore germination after incubation of 6 h at 35 and 40°C.

Host range and effect of age of mungbean seedlings on MYMV transmission

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The Mungbean or green gram (*Vigna radiata* L.) is the third most important pulse crop grown in India after chickpea and pigeonpea. MYMV is most devastating disease on mungbean and having wide host range including weed and related crop hosts. In an experiment conducted, out of 24 different plant species belonging to two families viz., *Leguminosae* and *Solanaceae*, were transmitted with Mungbean yellow mosaic virus (MYMV) through whitefly (*Bemisia tabaci*) vector, only five crop plants viz., soybean (*Glycin max* (L.) Merr.), pigeonpea (*Cajanus cajan* (L.) Millsp.), black gram (*Vigna mungo* (L.) Hepper), horse gram (*Macrotyloma uniflorum* (Lam.) Verdc.) and frenchbean (*Phaseolus vulgaris* L.) belongs to *leguminosae* were infected with MYMV with per cent transmission of 40, 13.33, 86.66, 80 and 60 per cent respectively. Healthy *B. tabaci* were allowed separately to feed for 24hrs on infected leaves and 10 viruliferous whiteflies were released on each seedling for 24 hrs of inoculation access period (IAP) for evaluating age of seedlings at which maximum MYMV infection take place. The experiment marks that the seedlings with early inoculation recorded highest per cent transmission. In 10 days old seedlings per cent transmission was 93.33 followed by 15, 20, 25 and 30 days old seedlings were 80, 66.66, 46.66 and 33.33 per cent transmission respectively. As the age of the seedling increases, the per cent transmission decreases.

Field monitoring virulence of *Pyricularia oryzae* in southern dry zone of Karnataka

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Rice is a vital staple food crop and is one of the pillars for the food security of India. It is one of the principal cereal crop cultivated in southern dry zone of Karnataka. Blast caused by the *Pyricularia oryzae* Cavara is the most severe and economically important disease of rice in command areas of the Southern dry zone of Karnataka. Breeding blast resistant varieties against the prevalent varying strains of pathogen that evolve and mutate is both complex and time consuming. Host specificity as well as genetic instability of rice blast fungus is the major cause for the breakdown of resistance in many varieties over a period of time. To develop resistant variety clear knowledge of the virulence structure of the pathogen population is requisite. In this context and attempt is made to monitor the virulence pattern in Mandya of southern dry zone of Karnataka. Twenty five international blast differentials comprising single or multiple blast resistance were used for monitoring the virulence pattern of *Pyricularia oryzae* under natural epiphytotic condition at Zonal Agricultural Research Station, VC Farm Mandyauring Kharif 2014 to 2016. Out of 25 host differentials screened, Tetep (*Pik-h; Pitp(t)T*) Tadukan (*Pi38(t); Pi-ta*), *O. minuta* (*Pi 9*), Zenith (*Pi-z + Pi-a + Pi-l*) and Raminad Strain 3 (unknown) showed resistant reaction with A and B lesion type with score < 3. Two varieties HR-12 (Himmayadut rice) and Co-39 (Amravathy) were susceptible with Score > 7 while, the remaining showed moderate resistance. The dendrogram of the reaction of genotypes across the 23 locations of India revealed six groupings. The virulence type of Mandya was grouped in group 5. The resistant lines can be utilized for developing durable resistant varieties/hybrids for the successful management of this disease in southern dry zone of Karnataka .

Survey for the wilt / foot rot complex disease incidence in major betelvine growing districts of northern Karnataka

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Betelvine (*Piper betel* L.) is an important horticultural crop of commercial values which belongs to family *Piperaceae*. The crop is a perennial climber cultivated for its leaf throughout the country. Damage of the crop due to wilt / foot rot complex disease may leads to total crop failure. As this crop susceptible to many diseases, foot rot complex caused by *Phytophthora* sp., *Rhizoctonia solani*, *Macrophomina* sp. and *Fusarium* sp. are the important pathogens associated with the disease. A roving survey was conducted to know the wilt / foot rot complex disease incidence in major betelvine growing parts of northern Karnataka Viz., Haveri, Uttara kannada, Bagalkot, Belagavi and Vijayapura. Totally 74 fields belonging to 26 villages of eight taluks in five districts were surveyed and the results revealed that the per cent disease incidence was ranged from 05-92 per cent. Out of five major betelvine growing districts, the maximum per cent disease incidence of wilt / foot rot complex of betelvine was recorded in Haveri district (67.46 %) and the lowest per cent disease incidence was noticed at Belagavi district (28.06 %). The major symptoms recorded during the survey were water soaked lesions with necrotic spots on leaves, black lesions on the collar portion of the vine as well as on stem and wilting of plants.

Survey and surveillance of important horticultural crop diseases of Haveri district

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Survey was carried out during *Kharif* of 2016-17 for the major prevalent diseases of horticultural crops in Haveri district. During the survey, fields were randomly visited and the disease incidence in each of the crop was recorded. Survey revealed that maximum incidence of cabbage black rot was recorded to an extent of 40-60% in Hirekerur taluk. The other prevalent diseases causing maximum incidence was powdery mildew in chilli noticed in Haveri taluka (20-25 %). The early blight of tomato was recorded up to 30% in Ranebennur taluk. The least incidence of the disease was (10-15 %) in Savanur taluk. *Rizhoctonia* wilt (15-20%) was noticed in china aster in Byadgi taluk. Beans mosaic (20-25%) was observed in Hangal taluk. Guava wilt (15-20%) was recorded in Shiggaum taluk. Other diseases of economic importance included *Fusarium* wilt in chilli (15-20%), Banana (10-15%), onion stem twisting (20-25%), Bacterial wilt in brinjal (10-15%), powdery mildew in Cucumber (25-30%), yellow vein mosaic in bendi (5-10%) and powdery mildew in cluster bean (30-35%). The predominant disease varied each according to taluk and the major horticultural crops grown in the area.

Survey of mango anthracnose caused by *Colletotrichum gleosporioides* in north eastern Karnataka

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Mango (*Mangifera indica*) is the most important fruit crop in the world as well as in India, called the king of fruits. Anthracnose of mango caused by *Colletotrichum gleosporioides* is among those diseases responsible for low yield of crop in India. The apparent symptoms can be observed on both vegetative and reproductive structure. Tiny dark brown to black spots appear at first which enlarge and join together and kill the blossoms before the production of fruit. Survey of mango orchards in North Eastern Karnataka showed the prevalence of Mango anthracnose at all visited locations. Maximum per cent disease index on vegetative parts was observed in Bidar district with mean PDI of 22.41 and least in Kalaburgi with mean PDI of 17.58. On inflorescence maximum per cent disease index of 12.44 was also observed in Bidar district and least PDI of 9.82 in Raichur district. Among the different varieties, Alphonso recorded maximum per cent disease index of 24.12 followed by Totapuri (22.67) and Mallika (20.66). Dasehari recorded least PDI of 14.87 followed by Malgoa (16.83) on vegetative parts.

Survey of pokkah boeng disease of sugarcane in north Karnataka

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Many biotic and abiotic stresses are affecting the sugarcane production among the diseases of sugarcane reported from Karnataka Pokkah boeng caused by *Fusarium moniliforme* is playing a vital role due to its economic threats in north Karnataka. The earliest symptom of pokkah boeng is a chlorotic condition towards the base of the young leaves and occasionally on the other parts of the leaf blades. Frequently, a pronounced wrinkling, twisting and shortening of the leaves accompanied the malformation or distortion of the young leaves. The base of the affected leaves is seen often narrower than that of the normal leaves. In affected mature leaves, the irregular reddish stripes and specks are observed within a chlorotic part. The reddish area sometimes develops into the lesions of a rhomboid shaped, which showed no definite arrangement or formed ladder like lesions, with dark edges in longitudinal rows, which turned the dark reddish to brown color, producing a burned appearance. Leaf sheaths are also observed with chlorotic conditions in some cases. Later, irregular necrotic areas of reddish color, similar on the leaf blades are also noticed on leaf sheath and midribs.

Recent survey during 2013 - 16 showed that increasing trend of disease incidence and most of the commercial cultivars are affected by the disease and the losses ranged from 4% - 37%. Although Pokkah boeng comes under minor concern but these days it is going to be major disease on basis of their rapid spread during last few years.

Studies on pathogenicity of root-knot nematode *Meloidogyne incognita* on turmeric

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Turmeric is one of the important spice crops grown in India since the times immemorial. It is used as condiment, dye, drug and cosmetic in addition to its use in religious ceremonies. India is a leading producer and exporter of turmeric in the world. Root-knot nematode (*Meloidogyne* spp.) is one of the major problem, which causes galls/knots in the rhizomes and causes considerable yield losses. A pot study was conducted to assess the pathogenicity of *Meloidogyne incognita* on turmeric at different inoculum densities (0, 10, 100, 1000, 5000 and 10000 J₂ per pot). The progressive reduction in growth and yield parameters with the increasing inoculum levels of *M. Incognita* was observed. However, plant height of 44.33 cm was recorded in plants inoculated with 10000 J₂ per pot as against maximum of 69.67 cm in plants inoculated with 10 J₂ per plant. The least rhizome fresh weight (181.00 g) and dry weight (35.67 g) was recorded in plants inoculated with 10000 J₂ per pot. The soil nematode was highest in plants inoculated with 5000 J₂ per pot (3610) followed by 10000 J₂ per pot (2660) and least in pots inoculated with 10 J₂ per pot (95.33). The highest number of galls per plant was observed in plants inoculated with 10000 J₂ per pot (107.33) followed by 5000 J₂ per pot (101.33). Reduction in growth and yield parameters and increase in number of galls was observed with increase in inoculum levels of *M. incognita*.

Spatial distribution of Mungbean Yellow Mosaic Virus (mymv) in north eastern Karnataka (NEK) region

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A roving survey was undertaken to know the spatial distribution of MYMV in six districts of north eastern Karnataka (NEK) region viz., Bellary, Bidar, Koppal, Kalaburgi, Raichur and Yadgir during *kharif* 2016. The GPS position and per cent disease incidence of MYMV in each location, stage of the crop, varieties grown, whitefly population at the time of visit, symptoms on mungbean and surrounding weed hosts were also recorded. Yellow mosaic incidence was present ubiquitously in all the six districts. The results revealed highest disease incidence at Koppal (33.33%) followed by in Bellary district (21.45%), Raichur (17.71 %) and Kalaburgi (17.44 %) district. The lowest was recorded in Bidar (5.66%) followed by in Yadgir (15.76%) district. Highest incidence in Koppal and Bellary districts was due to dry weather before and during the crop season favorable for whitefly perpetuation and spread of MYMV. Blackgram and mungbean cultivated during summer under irrigated conditions in both the districts were infested by MYMV and virus inoculum was carried forward to succeeding *kharif* sown greengram crop. During offseason, whiteflies were found to survive on weed hosts and other legume crops. Lower incidence of MYMV noticed in Bidar district followed by Yadgir was mainly due to unfavorable weather factors like lower temperature and higher rainfall during the mungbean cultivation which is detrimental to whitefly development and multiplication.

Survey to study the spatial distribution pattern of bud blight disease of tomato in Northern Eastern Karnataka through global positioning system (GPS)

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Tomato (*Solanum lycopersicum*) belongs to the family Solanaceae is one of the important vegetable crops across the world. In India, it is grown in 905.5 ('000 ha) area with 19103.99 ('000 MT) production and 20.8 (MT/ha) productivity. In the recent years, tomato is being grown extensively in Karnataka. Tomato suffers from fungal, bacterial and viral diseases. Among the viral diseases, bud blight disease of tomato caused by *Peanut bud necrosis virus* (PBNV) is a serious problem in north eastern Karnataka. Present study was conducted to investigate the disease incidence, field diagnostic symptoms and spatial distribution of bud blight disease of tomato through GPS system approach. It revealed that disease was found at all growth stages of the crop with characteristic symptoms such as necrotic rings with green hallow on leaves, tip necrosis, presence of longitudinal brown streaks on the petioles, stem and chlorotic ring spots on red ripened fruit. GPS based survey indicated, per cent disease incidence varied with location. Among the six districts, highest incidence of 62.13 per cent was recorded in Kalaburgi district followed by Raichur, Bidar, Yadgir and Koppal with 60.35, 57.96, 45.68 and 37.13 per cent, respectively and least disease incidence 14.25 per cent in Bellary district. GPS maps plotted based on PDI scale (0-4) represents high risk areas of the disease and higher magnitude of disease was recorded in many of the location surveyed were the tomato fields were surround by alternate host crop for PBNV.

Effect of different levels of pigeonpea cyst nematode inoculum on growth parameters of pigeonpea

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Pigeonpea (*Cajanus cajan* L.) is a major pulse crop of India providing much of the protein supplement to vegetarian population. The pigeonpea cyst nematode, *Heterodera cajani* Koshy causes significant loss in crop yields. A pathogenicity test was carried out to know the level crop damage caused by the nematode. The test was carried out under glass house condition during 2015-16. The seeds of pigeonpea variety GS-1 was collected and sown in 20 cm diameter earthen pots filled with autoclaved soil and inoculated with *H. cajani* after 15 days of germination at 0, 10, 100, 1000 and 5000 nematodes/ pot. The observations such as shoot length, fresh shoot weight, dry shoot weight, root length, fresh root weight, dry root weight, total biomass, number of cysts per plant, number of eggs per cyst and number of nematodes per 200 cc of soil were recorded at 120 days after inoculation. The results revealed that the length of shoot was found to decrease with the increase in inoculum levels of nematode. The maximum shoot length (85.02 cm), fresh weight of shoot (14.13 g), dry shoot weight (6.38 g) was recorded at zero inoculum level. The lowest shoot length (35.28 cm), shoot weight of (2.83 g) at 5000 J2 per pot. Maximum number of cysts (103.25 cysts/ plant), number of nematodes (4098.75) per 250 g of soil was recorded at 5000 J2 inoculum level and lowest number of cysts (17.25 cysts/ plant), minimum number of nematode per 250 g of soil were recorded at 10 J2 inoculum level i.e. 555.

Different modes of transmission and virus-vector relationship of leaf curl disease of mesta in relation to disease spread

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Mesta (*Hibiscus sabdariffa*) is one of the most important commercial fibre crops after cotton and jute, which belong to the family Malvaceae. The crop is mainly grown for a green leafy vegetable purpose in North Karnataka, India. Mesta crop is being affected by many diseases of which leaf curl disease caused by *Begomovirus* is a main constraint in its production. The disease is observed to be transmitted by different means mainly by whitefly (*B. tabaci*), dodder (*Cuscuta sp.*), grafting and sap. The maximum disease transmission was observed by whiteflies (90.66%) followed by dodder (73.33%), grafting (60.00%) and sap (34.41%). Single whitefly is efficient to transmit the disease (40%) but 100 per cent transmission was obtained by 20 whiteflies per plant. Similarly a minimum 10 min of Acquisition Access Period (AAP) and Inoculation Access Period (IAP) is required for the disease transmission but the maximum transmission of 100 per cent was observed in 12 h of AAP and 24 h of IAP, which reveals that there is a positive correlation between the number of whiteflies, AAP and IAP with disease transmission. However, persistence of leaf curl virus in viruliferous whiteflies (*B. tabaci*) revealed that, the virus may persist up to seven days with serial transmission and exhibits the disease symptoms. Infected plants exhibited the characteristic symptoms of vein clearing, chlorosis of young leaves, followed by vein thickening, upward curling of leaves, formation of enations, rough leathery leaves, twisting of petioles, reduced leaf size and stunted growth.

Incidence of cucumber mosaic virus (CMV) in FCV tobacco an emerging problem in Karnataka light soil region

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Flue-Cured Virginia (FCV) tobacco is the major commercial crop in southern transitional zone of Karnataka. FCV tobacco is being grown in *Kharif* as rainfed crop with more institutional support and sustained demand in the international market. The crop is susceptible to many biotic and abiotic stresses. Among diseases damping off, blackshank root-knot nematode, TMV and leaf curl have become potential threat for the successful cultivation of this crop. The most common symptom is a typical mosaic and shoe tail, but mosaic symptoms can be confused with TMV. CMV has a wide range of host plants and is vectored by aphids. Generally, in KLS region solanaceous and cucurbitaceous vegetables are commonly grown throughout the year. The most common viral disease is CMV in all the seasons. The same viral infection was observed in FCV tobacco which exhibits filiform or shoe tail symptoms. This CMV can only induce quite frequently filiform type symptoms (thread- or filament-shaped) in newly formed leaves which can be more or less marked when they are moderate. The leaves are simply narrower than usual, they can affect only a portion of the lamina, such as its tip. In extreme cases, the leaves are reduced to midrib only. And it was also observed that the presence of tobacco aphids on lower surface of the leaves. Normally, the symptoms first appear in the borders of the tobacco fields with close proximity to weeds. Scanning of the literature revealed that, there are no reports about this new viral symptom in tobacco in India. However, further investigations are required in this line for confirmation and for designing suitable management practices.

A new report on maize nematodes- an emerging problem in southern transitional zone of Karnataka

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Maize (*Zea mays*) has occupied a major junk of area since 15 years in Karnataka and in several tracts it is cultivated as mono crop year after year. Diseases like turicum leaf blight, maydis leaf blight, downy mildew, charcoal rot, stalk rot and cyst nematodes are causing serious damage in maize. In July, 2015, during a survey of maize fields in Shikaripura region of Shivamogga district of Karnataka, five species of nematodes belonging to different genera viz., *Tylenchorhynchus*, *Pratylenchus*, *Helicotylenchus*, *Criconemaoides* and *Trichodorus* were noticed. The infected plants showed symptoms of nematode damage such as yellowing of leaves, stunted plants, stubby roots, bare roots and swollen roots. The above nematodes were isolated and identified. The field observation showed plants with the similar symptoms spread across the maize cultivation in Shivamogga district. The literature scanning reveals that, there are no such reports either from Karnataka or India. It appears that this is the first report of *Tylenchorhynchus*, *Helicotylenchus*, *Criconemaoides* *Pratylenchus* and *Trichodorus* spp in Maize crop in Karnataka or India. The outbreak of these nematodes will pose a new challenge for crop management. Farmers are unaware about the nematode disease. Further investigations are required for confirmation and management aspects of these plant parasitic nematodes.

Prevalence of leaf rust (*Puccinia triticina* Eriks.) races and slow leaf rusting mechanism in peninsular zone (PZ) released wheat genotypes

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Peninsular zone plays an important role in cultivation and production of quality wheat grains in Indian subcontinent. Also it acts as secondary foci of infection for the destructive fungal disease of wheat i.e leaf rust caused by *Puccinia triticina* Eriks. The pathogen being an obligate organism has high evolution potential leading to development of races. The cultivation of rust resistant wheat genotypes in peninsular zone has lead to evolution of many races belonging to different pathotype groups. In the present investigation, the pathotype group 77 was dominant on peninsular zone released wheat genotypes. Five different pathotypes of *P. triticina* were observed on nine samples. Pathotype 77-9 was most frequent and appeared on four genotypes (Amruth, PBN 51, NIAW 34 and NI 5643) followed by 77-5 which was appeared on two genotypes (NIAW 34 and NI 5749). Slow rusting is an important mechanism which reduces leaf rust disease spread in wheat. Studies on components of slow rusting such as latent period, uredial density, uredial size and AUDPC in selected 13 peninsular zone wheat genotypes revealed that there is wide variation among different components of slow rusting resistance from genotype to genotype. The genotype MACS 6222 has not taken any infection and remains free throughout the course of study. Based on the slow rusting components five genotypes (UAS 415, UAS 446, UAS 334, UAS 347 and HD 2189) were considered as slow rusters and remaining three (UAS 304, MACS 6222 and GW 322) as resistant, two (DWR 2006 and Bijaga yellow) as moderately resistant and three genotypes (UAS 428, DWR 162 and DWR 195) as fast rusters.

Mapping out of major hemibiotrophic foliar fungal diseases of soybean in parts of northern Karnataka

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The roving survey on severity of major hemibiotrophic foliar fungal diseases of soybean was conducted during *khari* 2016 in major growing districts of northern Karnataka. The data revealed that the maximum average disease severity (41.94 PDI) of anthracnose was observed in Bailahongal taluk of Belagavi district and the minimum severity was noticed in Bidar taluk of Bidar district (33.06 PDI). The maximum average disease severity (29.29 PDI) of *Alternaria* leaf spot was observed in Shiggaon taluk of Haveri district and the minimum severity was noticed in Dharwad taluk of Dharwad district (21.88 PDI). With respect to *Cercospora* leaf spot the maximum average disease severity (18.25 PDI) was observed in Haveri taluk of Haveri district and the minimum severity was noticed in Dharwad taluk of Dharwad district (6.13 PDI). The maximum severity of anthracnose (49.55 PDI), *Alternaria* leaf spot (32.63 PDI) and *Cercospora* leaf spot (20.06 PDI) was recorded on variety JS 335. Further, latitude between 14°N to 15°N recorded highest disease severity of anthracnose (40.38 PDI), *Alternaria* leaf spot (28.46 PDI) and *Cercospora* leaf spot (11.98 PDI). As the latitude increased from 15°N to 17°N diseases severity showed a declining trend. With respect to longitude revealed that maximum severity between 74°E to 75°E. Severity of foliar diseases showed an increasing trend from 400m of elevation to 700m. However, maximum severity was observed at 400 to 500m elevation in all the diseases. The maximum severity of 42 PDI was recorded with respect to anthracnose, 28.45 PDI in *Alternaria* leaf spot and 13.60 PDI in *Cercospora* leaf spot at an elevation of > 700 m from mean sea level. The study identified for the first time, the association of severity of various hemibiotrophic diseases with elevation of different locations using GPS.

Prevalence of sterility mosaic disease in major pigeonpea (*Cajanus cajan* (L.) Millsp.) growing areas of southern Karnataka

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To identify hot spots sterility mosaic disease (SMD) of pigeonpea, an extensive roving survey was undertaken in major pigeonpea growing areas of southern Karnataka viz., Bengaluru Rural, Ramanagara, Chikballapur, Kolar, Tumakuru, Hassan and Chitradurga during 2014-15. The diagnosis of the disease in the field was based on symptoms on the plants. The per cent disease incidence was calculated randomly in different locations. Pigeonpea sterility mosaic disease incidence in southern Karnataka varied from 0 to 80 per cent. Among the seven districts of southern Karnataka surveyed, maximum mean incidence was recorded in Tumakuru (37.7 %) followed by Ramanagara (29.3 %), Bengaluru Rural district (25.7 %), Chikballapur (18.5 %) and Chitradurga (18.4 %). The minimum mean incidence was recorded in Kolar (7.6 %) followed by Hassan (11.5 %). Highest disease incidence was recorded in off-season pigeonpea plants grown in the form of ratoon and perennial plants and in the irrigated tracts of pigeonpea growing areas which influenced the micro climatic conditions favourable for multiplication of the vector.

Survey for the severity of bacterial leaf blight in major rice growing districts of southern transition zone of Karnataka

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Bacterial leaf blight of rice caused by *Xanthomonas oryzae* pv. *oryzae* is one of the major biotic constraint in Karnataka. The disease known to occurs at all the stages but infection at the tillering stage causes severe blighting of leaves resulting in yield loss upto 75% depending on weather, location and rice cultivar. Thus, an intensive roving survey was conducted during *Kharif* 2016 to know the extent of bacterial leaf blight intensity on rice. The survey was taken up in farmer's field of Shivamogga, Davanagere and Chikkamagaluru districts of Southern transition zone of Karnataka. In each field 10 plants were randomly selected in zig-zag manner. Disease severity on randomly selected 10 plants in each field was recorded by following 0-9 scale developed by (Anon., 1996). The results revealed that the disease severity ranged from 13.89 to 62.22 per cent. Among the three surveyed districts results indicated that the highest disease intensity of 34.64 PDI was observed in Shivamogga and lowest disease intensity of 21.02 PDI was documented in Chickamagaluru district. Taluk wise disease intensity revealed that the highest PDI of 47.33 recorded in Shikaripura taluk and lowest PDI of 16.53 was observed in Koppa taluk. The variation in bacterial blight intensity in different locations was attributed mainly to the environmental conditions and cultivation practices of the farmer such as date of planting, irrigation, fertigation and plant protection measures.

Distribution of sunflower necrosis disease and thrips vector in major sunflower growing districts of Karnataka

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Sunflower necrosis disease (SND) was reported to cause a significant damage to sunflower production in India. The survey was conducted to document the occurrence of sunflower necrosis disease and thrips vector in major sunflower growing districts of Karnataka viz., Vijayapura, Bagalkot, Dharwad, Belagavi, Gadag, Haveri, Kalaburagi, Raichur, Chitradurga and Bengaluru during 2015-16 and 2016-17. The survey results revealed that the incidence of sunflower necrosis disease and mean thrips population was ranged from 0 to 28.57 per cent and 0 to 5.4 thrips per plant, respectively. Among the districts surveyed, the highest per cent incidence of SND was recorded in Bagalkot district (15.24) followed by Vijayapura (12.85) and Bengaluru (12.66), whereas lowest per cent SND incidence was recorded in Kalaburagi district (6.82). Similarly, the highest average thrips population (mean of five plants) was recorded in Bagalkot district (2.6) followed by Vijayapura (2.4) and Bengaluru (2.3), whereas lowest was recorded with Kalaburagi district (0.8). The per cent disease incidence and thrips population was in parity.

Epidemiology and management of pomegranate (*Punica granatum* Linn.) wilt (*Ceratocystis fimbriata* Ell & Halst)

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Pomegranate is one such fruit which assures the farmers a good profit. Unfortunately a wilt caused by *Ceratocystis fimbriata* is occurring in a devastating form in India, China and Pakistan since 40 years destroying large number of pomegranate gardens causing heavy losses to the farmers with range from 3.5 to 80 per cent. Systematic survey on pomegranate wilt incidence was carried out in India (1996 -2015) and it contributed 8.69 per cent wilt incidence with monetary loss about 5.43 cores. Above 5 years plants were infested with scolytid beetle (*Xyloborus fornicatus*) in the collar regions (0.41%). Due to severe wilting, the farmers were replaced pomegranate crop with grapes, sapota, cotton, papaya, lime, and banana. The wilt occurs at any stage of the crop starting from seedlings to old plants. The wilt occurs more in black soil than compared other soils due to heavy moisture contents. The various symptoms are: all the leaves in the plant turns to yellowing/light green colour; yellowing of leaves in the single branch; sudden wilting of leaves; complete wilting of the plant; epinasty symptoms; vertical stem cracking; blue stain patches on the bark. Brown / pink streak in the xylem. Pin holes with brown discoloration in the stem. The fungus, *Ceratocystis fimbriata* isolated from infected plant parts (stem, root, branches and bark) collected from 52 locations in India and confirmed the pathogen through pathogenicity. The pathogen was identified by IMI, UK and Iowa State University, USA as Latin American group. The fungus, *C. fimbriata* is the primary causal agent for wilt of pomegranate in India, Pakistan and China. Infected seedlings; irrigation water; root contact; implements; rain water; budding knife; secature and soil particles with wind are the major source for the spread of disease and the pathogen enters through wounds. The fungus, *C. fimbriata* isolated from the scolytid beetles and it may act as a vector for this pathogen. The fungus survives in the infected plant parts up to 190 days and in the soil for long time. The recent management strategies were developed for the management of wilt disease. Selection of disease free seedlings for planting, wider spacing, avoid movement of implements from infected areas to disease free areas and uproot of infected plants immediately in the garden and then soil sterilized with formalin (4%) and Basamid (30 g/sqm) reduced pathogen population in the soil and then take up new planting, soil trenching between infected and healthy plants to avoid root contact. The various new molecules of fungicides viz., propiconazole, tubuconazole, trifloxystrobin + tebuconazole, fenamidone + mancozeb, hexaconazole + zineb, difenoconazole, hexaconazole, chlorothalonil, mancozeb, captan, azostrobin, carbendazim etc., were evaluated and found that soil drenching of propiconazole (0.1 %) along with soil application of boric acid (50g/pl) were found effective. The various bioagents viz., *Trichoderma harzianum* (Th-2, Th-19, Th-20 ,Th-55,Th-58), *T. viride* (Tv-13, Tv-14, Tv-16, Tv-21, Tv-22, Tv-B1 Tv-B2,Tv-GKVK3,Tv-52,Tv-60), *Bacillus subtilis* and *Pseudomonas fluorescens* were evaluated under *In vitro* and found *Trichoderma viride* strains Tv-16, Tv-21 and *Trichoderma harzianum* strains Th-19, Th-55 ,Th-41 were showed cent per cent inhibition of *C. fimbriata* . The soil application of *Bacillus subtilis* with an interval of 15 days period to the initial stage of infection, the wilting plants were recovered after 30 days of application. The seedlings inoculation of VAM fungi viz., *Glomus leptotichus* and *Acaulospor laevis* were effective against wilt. The culture of *Bacillus subtilis*, Jasmine flower and *Lantana camera* extract from vermicompost were effective against *C. fimbriata*.

Magnitude, symptomatology and pathogenic spectra of root rot and heart rot of *Terminalia alata* and its associated species in Canara circle

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Terminalia spp. is one of the major components in the deciduous forest ecosystem and important timber yielding tree species in Canara Circle. Heart rot and root rot are major diseases which reduce the timber quality and production in natural forest. Survey results indicated the magnitude of heart rot and root rot in Yellapur forest division with average incidence of 27.59 per cent and 13.72 per cent and per cent disease index (PDI) of 23.17 and 13.07 respectively in natural stands. Manchikere range recorded highest heart rot incidence (35.72%) and PDI (28.14) and the least was of 22% and 19.25 respectively were recorded in Mundgod range. Similarly Manchikere range showed highest root rot incidence (21.09%) and PDI (19.72) and least incidence (6.36%) and PDI (6.36) was recorded in Yellapur range. The highest disease severity of 2-5 was recorded from Manchikere, Katur and Mundgod ranges and least was of 1-4 were recorded from Yellapur range. The characteristic symptom of heart rot of *Terminalia* were swollen bole, punk knot, branch drying, bark splitting, fruiting bodies on the stem and tree mortality. Root rot in *Terminalia* showing the symptoms of presence of bracket type fruiting body near the base of trunk, naked dried branches, root dissolution, decay of sapwood and death. The major associated tree species of *Terminalia* spp. affected were *Xylia xylocarpa*, *Lagerstroemia macrocarpa*, *Anogeissus latifolia*, *Carea arborea*, *Dillenia pentagyna*, *Dalbergia latifolia*, *Madhuca latifolia* and *Grewia tilifolia*. The morphological and cultural characterization of wood decay fungi from *Terminalia* spp. included *Ganoderma lucidum*, *G. applanatum*, *G. colosum*, *Daedalea flavida*, *D. quercina*, *Hexagonia apiaria*, *H. tenuis*, *Trametes versicolor*, *T. suaveolens*, *Cantherallus* spp., *Polyporus xanthopus*, *Lenzites betulina* and *L. adusta*.

Epidemiological study of early blight of tomato caused by *Alternaria solani*

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Early blight caused by the fungus *Alternaria solani*, is perhaps the most common foliar disease of tomato (*Lycopersicon esculentum* L.) in the world, leading to a reduction of economic fruit yield. An experiment was conducted in department of Plant Pathology to study the about the epidemiology of early blight disease. The cultural studies showed that, the mycelium was haploid and septate, becoming dark pigmented with age. Further, Sporulation in culture was stimulated by exposure to fluorescent light. The asexual conidia are borne singly or in a chain of two on distinct conidiophores. The beaked conidia normally possess 9–11 transverse septae. For the above said disease, pathogen was isolated and pathogenicity was proved. PDI was calculated with reference to standard weeks from 16 to 22 week. The initial disease record recorded at 30 DAS, further, it had shown that disease progress as number of days after sowing goes on increasing. The values of PDI were recorded highest (100%) 79 DAS onwards. The results show that PDI ranged from 10-100 per cent. The area under disease progress was recorded as 2961. Further, time from initial infection to appearance of foliar symptoms was dependent on environmental conditions favouring the disease and age of plant was also influenced the disease development.

Epidemiology, survival and management of citrus canker caused by *Xanthomonas axonopodis* pv. *citri* (Hasse)

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Canker is one of the most devastating diseases, affecting the major cultivated species of citrus. The disease cause an extensive damage to the crop and severity of infection varies with species, varieties and prevailing weather conditions. The disease appeared as a serious problem, where ever Kagzi lime (*C. aurantifolia*) is grown on a large and commercial scale (e.g., Akola region in central India, Nellore and Periyakulum regions in Southern India and Khera region of Western India) and is becoming a big constraint for the citrus production. With regard to management practices, different antibiotics, antibacterial chemicals and bio agents were evaluated against the pathogen by in vitro. Weather factors such as temperature, rainfall and RH played a significant role in disease buildup and spread. Initial infection occurred during 2nd week of August with 21.62 percent incidence and 32.14 per cent severity (PDI) on fruits. The disease spread and reached the peak incidence (78.86%) and severity (82.25 PDI) during 3rd week of October owing to the congenial weather. Correlation between the disease and weather factors revealed that, increase of maximum temperature had a significant positive correlation with disease spread. Rise in minimum temperature is non significant and had a negative correlation with disease severity. The continuous rainfall irrespective of amount always favored the disease development and spread. Influence of RH is positively correlated but not significant. Survival ability of the pathogen in the infected plant parts indicated that, the pathogen can survive up to 150 days in the infected leaf and twig residues kept under sterilized and unsterilized soil conditions. Among the different antibiotics and antibacterial chemicals evaluated against the pathogen, the streptomycin 0.10% was found significantly effective with maximum inhibition zone of 18.96 mm followed by K-cycline (17.86 mm) and COC (13.66 mm). The other chemicals viz., tagmycin, bacterinashak and plantomycin were found moderately effective and Bionol-100 was least effective with an inhibition zone of 6.89mm. Among the five biocontrol agents tried, *Bacillus subtilis* (16.16 mm) and *Pseudomonas fluorescens* (14.63 mm) were found were found very effective in inhibiting the growth of the pathogen. The fungal biocontrol agents viz., *Trichoderma viridae* and *Trichoderma harzianum* were found totally ineffective.

Host range and virus vector relationships of Croton Leaf Curl Virus (CrLcCuV)

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Croton leaf curl virus was found to be transmitted only to the species viz, *Nicotiana tabaccum* cv. *Samsun*, *N. benthamiana*, *N. tabaccum*. Downward curling and reduction in leaf size were the common symptoms on the CrLcCuV inoculated *Tobacco* spp. The plants species viz., *Euphorbia geniculata*, *Lycopersicon esculentum*, *Ageratum conyzoides*, *Manihot esculenta*, *Jatropha gossypifolia* and *Gossypium hirusutum* did not show any visible symptoms upon inoculation with *B. tabaci*. A minimum of 25 adult *B. tabaci* whiteflies per plant were required for transmission (10 %), while 50 adult whiteflies per plant gave 60 per cent transmission of virus. Studies on virus vector relationship revealed that the whitefly *B. tabaci* required minimum AAP and IAP of 12 hr each respectively for virus transmission. Maximum transmission (50 %) of the virus was achieved with AAP and IAP of 48 hr each. The disease was transmitted through grafting, stem cuttings and whiteflies *B. tabaci*. 100 per cent transmission was achieved through grafting and cuttings. But the percentage of transmission from croton and to croton through whiteflies was below 40 per cent.

Incidence of grape powdery mildew in Vijapur and Bagalkot district of Karnataka - A survey

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Grape (*Vitis vinifera*) is basically a sub-tropical fruit crop. However, in India, grape is cultivated under tropical conditions for their excellence. In India Grape is cultivated over an area of 1.23 lakh ha with a total production 26.35 lakh tons and productivity of 21.4 tons/ha. Grape growing district in Karnataka are Vijapur, Bagalkot, Belagavi, Bengaluru and Kolar. The major diseases of grape are downy mildew, powdery mildew and anthracnose. Now a days powdery mildew is becoming major disease due to occurrence of favourable weather condition. The disease is caused by a fungus, *Erysiphe necator* (Schw.) Burr. A roving survey was conducted during November 2016 to February 2017 in Vijapur and Indi taluks of Vijapur and Jamakhandi taluk of Bagalkot district. A total 99 farmers vineyard were selected and recorded geographical coordinates using handheld GPS. Field wise disease severity was recorded at five times with an interval of 20 days. Average per cent disease incidence was maximum in Jamakhandi (12.6%) and Vijapur (13.3%) were observed during January and February 2017 and least per cent disease incidence was observed during November and December 2016 indicating a temporal variation in the disease incidence. Based on the spatial and temporal variation, severity of disease was more in Jamakhandi during January and February due to contiguous spread of vineyards which favoured the easy spread of inoculums. Apart from this, it is a predominately sugarcane growing area which creates high humid local microclimate favouring the development and spread of Powdery mildew disease. From the survey it was noticed that, farmers were not going for intensive disease management using fungicides, fearing residue remaining in the harvest which may degrade the export quality and raisin quality.

Characterization of symptoms of dry root rot of disease caused by *Rhizoctonia bataticola* in chickpea

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Chickpea (*Cicer arietinum* L.) is one of the most important food legumes being cultivated in almost all over the world including temperate and sub-tropical regions. Chickpea cultivation is often subjected to significant yield losses due to insects and diseases ranging from 5-10% in temperate and 50-100% in tropical regions. To study on the disease incidence and symptomatology, a roving survey was conducted to record the occurrence and distribution of dry root rot of chickpea in 8 districts of the major chickpea growing areas in North-Eastern Karnataka viz., Bidar, Gulbarga, Yadagiri, Raichur, Koppal, Bellary, Bijapur and Dharwad during *Rabi* 2015. The symptoms of dry root rot were studied with respect to drying and death of plants; include chlorosis of petioles and leaflets, initially confined to top leaves of the plant. Leaves and stems of affected plants are usually straw coloured and in some cases, the lower leaves and stems are brown. The tap root turns black with signs of rotting and is devoid of most of the lateral and finer roots. The dead roots are quite brittle and show shredding of the bark. The tip of the root is easily broken leaving the lower portion of the tap root in the soil when plants are uprooted. Dark minute sclerotial bodies can be seen on the roots exposed and inner side of the bark or when split open at the collar region vertically.

Studies on rhizome rot disease complex of turmeric in northern part of Karnataka

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Turmeric (*Curcuma longa* L.) is one of the important spice crops grown in India since times immemorial. The major constraint for cultivation of turmeric is the rhizome rot disease complex. Roving survey was conducted during 2015 – 2016 in Belagavi and Bagalkote districts. The survey results showed that the highest mean per cent disease incidence was observed in Belagavi district (44.27 %) followed by Bagalkote (38.40 %). The analysis of rhizome rot samples collected during the survey revealed that *Pythium* (88.23 %), *Fusarium* (61.76 %) and *Sclerotium* sp. (35.29 %) were found to be involved in causing the rhizome rot of turmeric. Some samples yielded combination of these three pathogens. Few samples associated with root knot nematode *Meloidogyne* sp. (26.47 %) and all the samples were infected with bacterium *Ralstonia solanacearum*. Twelve different treatments were imposed for management of disease, Among significant reduction in the disease incidence was recorded in the seed treatment with metalaxyl-MZ (0.3 %) and soil application of *Trichoderma harzianum* (10 g/kg of soil) recorded least disease incidence (6.71 %) followed by soil application of streptomycin (0.05 %) + copper oxy chloride (0.3 %) recorded 8.75 per cent when compared to control (72.68 %) at 240 DAP.

Gummy stem blight disease incidence in water melon in Bagalkot district

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Water melon (*Citrullus lanatus* var. *lanatus*) is important fruit cum vegetable crop of tropical and subtropical countries. The crop is susceptible to so many diseases, to name few powdery mildew, gummy stem blight, anthracnose, mosaic and groundnut bud necrosis disease. To know the incidence of gummy stem blight disease incidence in Bagalkot district roving survey was conducted in the year 2015-16 and 2016-17 in three taluks namely Bagalkot, Bilgi and Badami. In the first year (2015-16) gummy stem blight disease incidence ranged from 5-10% in Bagalkot district whereas, zero per cent gummy stem blight disease incidence noticed in the second year (2016-17). Results revealed that due to change in climate there is reduction of disease incidence.

Technical Session V

Role of Extension plant protection in agriculture

Farmers field school – An effective participatory approach for plant health management

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In the changing scenario of agriculture one of the major problem faced by the farmers are in terms of plant health management. A great challenge for the farmers is identifying and managing the pest and diseases. The skill required could be imparted through Farmers Field School (FFS). It is a form of adult education which evolves from the concept that farmers learn optionally from field observation and experimentation. The term “Farmers’ Field School” comes from the Indonesian “Sekolah Lapangan” meaning simply “Field School”. The first Field Schools were established in 1989 in Central Java during the pilot phase of the FAO-assisted National IPM Programme. Farmers Field School for the first time was started for Integrated Pest Management in Rice. The main objective of FFS is to impart knowledge and skills to make them expert in their own farm and this helps them to improve their ability in solving problems and taking effective decisions. The major four principles of FFS are to grow healthy crop, regular observation of the field, protect the natural enemies of the pests and to make farmers expert in their own field. A typical FFS group consists of 25-30 farmers who meet once in a week in a local field under the guidance of trained facilitator. The major components of FFS are master trainers, facilitators, member farmers and demonstrator. This is one of the effective participatory approaches which helps the farmers to learn by comparing the conventional and experimental plots. Farmers Field School is one of the experiential learning in which farmer will learn from their own experience and take a decision on which is the best available practices for effective plant health management.

Co-operatives - A collective approach for pest management

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Pest management is a systematic approach for the management of agricultural pests based on their occurrence and season of incidence. Pest management needs multiple coordinated methods to control pests to economically accepted levels. Pest problem affects all the farmers but can be very difficult and challenging for small land holding farmers who have limited financial and technical resources. So there is a scope for cooperative approach in recent days for the pest management. Co-operatives are those which are formed by the group of farmers on voluntary basis based on their interest and needs by pooling their resources. Co-operatives have open and free membership wherein farmers can easily enter and exit from group based on their needs. There are different types of co-operatives like production co-operatives, credit co-operatives, marketing co-operatives and supply co-operatives. By using co-operative approach a group can be formed based on pests related to particular crop wherein the farmers can discuss about the occurrence of pests, symptoms, season and control measures. Group members can meet regularly on particular time to discuss about their problems, share their ideas and can find an effective way to control the pests in that area. The co-operatives not only help farmers to discuss their ideas but help farmers in production by supplying inputs and marketing of outputs. So cooperative helps the farmers to take collective decisions about pest occurrence on time which reduce the economic loss to the farmers.

Impact of extension methods in adoption of plant protection practices

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Technology transfer in Indian agriculture has been more than five decades old practice in ensuring green revolution through improving production and productivity of food crops. It covers technologies for crop improvement, crop husbandry, crop production and crop protection. The later has been not effective due to various reasons. Number of technologies are developed for management of crop diseases, but their practical utility by end users remained poor. The current study evaluates different extension methods engaged in technology transfer and suitable for adoption by farmers in their crop protection. Although both private and public institutes are working in technology transfer developed by them, private efforts and expenditure is more in this regard but profit oriented followed by service. In case of government approaches of technology transfer in plant protection through Krishi Vigyan Kendras (KVK), Extension Education Centers (EEC) and Research Stations, their technology transfer is of service oriented, equally efficient but poor in outreach. Lack of human resource was found to be the major reason. It was observed among farmers, that more the extension personnel contact, more they are convinced. Besides this, effectiveness of technology to build confidence and faith among end users played next important role in adoption. Although private institutes also engage staff but monopoly with fewer options to adopt makes it less attractive among the farmers but inevitable some time. The poor knowhow among the private extension personnel is another reason for failure of technology transfer by private institutes. Overall, it is direct contact between farmers and KVK, EEC pathologists and scientists' which makes technology transfer more effective for plant protection than any other methods currently practiced. The lack of poor diagnosis and suitable recommendation is the third possible reason for poor success in extension by private institutes which hardly happens in public institutes. Although input vendors decide more in delivering the plant protection measures but an educated farmer still has faith in personal contact with extension official for his needs of plant protection suggestions.

Management of basal stem rot in coconut through Indigenous Technology Know-how (ITK)

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Coconut is an important commercial plantation crop of Tumkur district in general and Tiptur region in particular. With the changing climatic conditions coconut growers are facing many problems like continuous drought during last four years, increase in pest like red palm weevil, black headed caterpillar, mites and diseases like basal stem rot, budrot and stem bleeding for sustainable coconut production. Among these problems, basal stem rot/Ganoderma wilt is one of the major problem leading to complete death of coconut palms. However, farmers are practicing their own Indigenous Technology Know-how (ITK) in managing basal stem rot which includes application of cow urine @ 10 liters/palm, + 1 kg Lime /palm+ 20 litres of cowdung slurry/palm, and *Trichoderma* @ 250 g/palm twice a year. In order to confirm the performance of farmer knowledge in managing the disease field demonstration was conduct to compare with existing recommended practice of opening of isolation trench around the palm and application of neem cake @ 5 kg/palm /year + *Trichoderma* @ 250 g/palm + 10 kg FYM twice a year and root feeding of hexaconazole @ 3ml/100 ml water/palm at quarterly interval. Results of the two years demonstration recorded that ITK is effective in improving growth of coconut palm besides reducing basal stem rot with 24 functional leaves after treatment compared to 15 leaves prior to treatment and two leaves drooped after treatment against eight leaves before treatment with a coconut yield of 68/ palm/year with BC ratio of 2.66 compared to 62/ palm/year with BC ratio of 2.47 in recommended practice.

Validation and promotion of integrated pest and disease management in tribal region of Shivamogga and Uttara Kannada districts of Karnataka

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Shivamogga district receives around 4000 mm of rainfall every year. It comprises hilly regions and also thick forest. Different types of crops like paddy, maize, areca, coconut, vegetables, pulses and black pepper etc. are being grown here. In and around Sagara taluk of Shivamogga district and Yellapura taluk of Uttar Kannda district. Especially, in Kargal area of Sagara taluk, where the world famous Jog falls is located and near the back waters of Sharavathi river, Hasalaru tribals are located in a village called Kudagunji. Further, near Savane village of Yallapura taluk Siddi tribals have started cultivation of lands in forest areas. Under Tribal Sub-Plan, these camps were visited along with ICAR-National Centre for Integrated Pest Management, New Delhi (NCIPM) scientists and Agriculture Department Officers. The information collected indicated that these tribal farmers are totally unaware of good agricultural practices. They are not in a position to differentiate between pests, diseases and nutrient deficiencies and without any knowledge of management practices. Further, it was revealed that hitherto, no training programmes/demonstration were conducted in their camps. Keeping this in view, training programmes were organized in collaboration with NCIPM and Agriculture Department at tribal camps. The beneficiaries were trained and educated regarding pests, fungal, bacterial, viral, plant parasitic nematodes and their impact on agricultural crops. The management of major pest and diseases was suggested in rice, vegetables and arecanut crops. Folders, booklets and critical inputs like *T. harzianum*, *P. lilacinus*, *P. fluorescens*, *B. subtilis* and carbofuran, chloropyrifos, carbendazim, tricyclazole and pheromone traps were distributed to the tribals as a ready reckoner for management. Front line demonstrations were also conducted for the benefit of participants and with their practical involvement. It was observed that they have never used any fertilizers and plant protection chemicals. The inputs provided were explained thoroughly along with time and mode of application and precautions. Methods of seed and soil treatments were demonstrated for management of pest and diseases. In both the training programmes nearly 100 tribals participated including tribal womens. The tribals are very confident about the IPM intervention and eager to continue and spread the message to fellow tribals regarding the incidence, spread and management of pest and diseases in future.

Effect of front line demonstration on management of yellowing in black pepper at Kodagu district

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Black pepper (*Piper nigrum* L.) the king of spices is a traditional spice crop which has been under cultivation since ancient times in India. Black Pepper is a woody climber and is a native of the Western Ghats of south India. In Karnataka, Black Pepper is mainly cultivated in Kodagu, Uttara Kannada, Dakshina Kannada, Shivamogga and Chikkamagaluru Districts. This crop is known to be suffering from many problems of which yellowing is a major constraint in its cultivation caused by nematodes, quick wilt disease and moisture stress. ICAR-Krishi Vigyan Kendra, Gonikoppal had conducted demonstrations on proven technologies on management of yellowing in black pepper at farmer's field of Tuchamakeri, Athuru and Kurchi village of Virajpet Taluk of Kodagu District during Kharif 2016-17. A total of 15 demonstrations were conducted in 2.0 ha area. Panniyur-1 was selected for the technology demonstration which is popular among farmers. The technology released by IISR Calicut for the management of yellowing was irrigation of vines during April to May, mulching of the base of the plant, soil application of phorate 10 gm per vine, spraying of black pepper special during April-May and September- October and drenching of microbial consortium during June and September was demonstrated in the farmers field. The farmers opined that, the technology is very effective in managing the yellowing in the vines. The outcome of the above demonstrations indicated that, in demonstration plots the per cent yellowing was 8.99 compared to 21.05 in farmer's plots. There was also significant increase in dry yield (4.63 q/ha) in demonstrated plots compared to (2.93 q/ha) in control plots. The BC ratio was also found higher in demonstration plots (3.28) compared to farmers plot (1.92). Hence, timely adoption of Integrated approaches is very effective in management of yellowing compared to farmer's practice.

Validation and promotion of nematode centric integrated pest management in rice in southern transition zone of Karnataka

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A validation programme in collaboration with National Centre for Integrated Pest Management, New Delhi, was taken up as an integrated approach to manage the major diseases and pests viz., root-knot nematode, blast, bacterial leaf blight and stem borer on rice in different taluks and villages of Shivamogga and Davangere districts. Three villages were selected based on rice cultivation practices viz., rice – rice – rice (Chi-kadakatte), rice – rice – greengram (Purale), rice - vegetables (Pillangere). Various activities carried out after the selection of nematode hot spot villages included balanced application of fertilizers, installation of pheromone traps for stem borer monitoring, release of *Trichogramma japonicum*, application of carbendazim (for blast), Streptocycline (for bacterial leaf blight), manual weed management. Systematic monitoring of insects, diseases and nematodes were carried out by organizing farmer field schools. Fields were visited once in a fortnight and the farmers were advised about the practices of integrated pest management in rice. Demonstrations and training programmes were conducted to train the farmers on IPM in rice. In nursery beds, carbofuran @ 0.3 g a.i./m², *Pseudomonas fluorescens* @ 20 g/m² were applied separately in the nursery beds for root-knot management. For need-based management of insect-pests and diseases, chlorpyrifos or imidachloprid and carbendazim or tricyclazole were sprayed. Awareness was created among the farmers regarding rice root-knot nematode as a main cause for death of the seedlings in nursery. Farmers were convinced about IPM practices as beneficial to them. There is an enhancement of yield up to 10 quintals/ha. Drastic reduction occurred in the incidence of root-knot nematode (i.e., 60-70%). The incidence of blast disease and stem borer was reduced. Reduction in number of chemical pesticide sprays from 8 to 2. Cost of cultivation was reduced up to 40%. Higher yields were recorded in carbofuran treated plots (2 q/ha). Enquiries were made by neighbouring farmers regarding the management practices adopted. In summer paddy season i.e., January, in the same nurseries the gall indices were very meager. The farmers are very confident about the IPM interventions and eager to continue and spread the message to fellow rice farmers regarding the incidence, spread and management of rice root knot nematode.

Comparative study of integrated pest management and farmers practices on sustainable environment in the rice ecosystem

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Rice is a staple food for more than sixty five per cent of the world's population but its productivity is limited by a number of biotic and abiotic stresses. Integrated Pest Management (IPM) is multifaceted approach which is ecologically safe, environmentally friendly to minimize the pest population and also to minimize negative impacts on the environment. This technique is an important step towards providing healthy, viable food for a growing global population. In Chi-kadakatte village of Davanagere district, Karnataka efforts were made to examine the impact of integrated pest management in a rice agro ecosystem. Initially, almost all the farmers rely on pesticides. IPM methods viz., healthy nursery, seed treatment with *Trichoderma viride*, seedling dip treatment with *Pseudomonas fluorescens*, installation of pheromone trap, use of balanced fertilizer were employed in our study which had an impact on the number of healthy tillers and hills and grain weight. The lowest percentage of dead heart (4.3) and white head (5.06) were found in the IPM treated plots. These plots had an average yield of 45q/ha. We found that there were significant differences among the treatments with respect to percentage of dead heart, grain weight and yield. There was an increase in number of tillers and reduction in nematode galls. The yields in other untreated fields of farmers were drastically low (37q/ha).

Supportive role of Plant Pathologist towards strong and comprehensive national and international plant biosecurity concerns

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Plant biosecurity has been defined as the protection of natural and managed plant systems from the emergence/introduction of diseases/ pests that would negatively affect the productivity, sustainability or diversity of plant systems. Threats to plants may be as a result of accidental or deliberate introduction of a plant disease/pest with the goal of reducing productivity or as a result of an introduction of contaminants that would render the resultant produce unusable. Experience from previous outbreaks and incidents demonstrated that it is essential that a high state of readiness is maintained to enable countries to deal with outbreaks in crops. Training and routine exercises are the key to maintaining overall preparedness. Accurate diagnosis can minimise the impact of a disease outbreak. With hundreds of host species and thousands of pathogen species, a plant diagnostician cannot be an expert on all plant systems. A holistic concept to address the issue of biosecurity needs to be evolved. Internationally, the agreement on the application of sanitary and phytosanitary measures of the WTO, governs SPS measures in relation to international trade. The Codex Alimentarius Commission (Codex), the IPPC and the Office International des Epizooties (OIE) provide international standards for food safety, plant health, and animal health, respectively. Further, the Cartagena Protocol of the Convention on Biological Diversity (CBD) applies to the transboundary movement, transit, handling and use of Living Modified Organisms (LMOs) The National Plant Diagnostic Network (NPDN) was created to link plant diagnostic laboratories throughout the United States to enhance diagnostic capability and increase sample capacity. The application of advanced computer, communications, and molecular technologies has enhanced NPDN's ability to detect rapidly outbreaks, to identify accurately newly introduced pathogens and insect pests, and to communicate securely that information to those with the authority and capability of responding effectively. Linking local, regional, and national plant diagnostic resources and expertise into global networks should become a priority for ISPP. Europe is particularly vulnerable to cross-border movement of introduced agents, and one response to this has been the recent revision of plant health regimes throughout the European Union. Other responses include project-based initiatives, such as PLANTFOODSEC. This may be of greater significance to resource-poor nations that lack modern diagnostic infrastructure and experience. Providing plant diagnosticians in resource-poor nations the access to global diagnostic expertise may reduce greatly the impacts of local disease outbreaks. Networking is essential for global plant biosecurity. Indian Plant Virus Database (IPVdb) (<http://220.227.138.213/virusdb/>) hosts information on plant viruses reported from India. The holistic approach to ensure biosecurity seeks to use the synergies of various existing sectors at the national level, without necessarily creating new structures. MoHA has the National Disaster Management Authority that can properly monitor and regulate the biosecurity issues. Besides, MoHA is also the nodal point of the National Crisis Management Plan 2003. The Agricultural Biosecurity Bill, 2013 was introduced in the Lok Sabha on March 11, 2013. Training and routine exercises are the key to maintaining overall preparedness.

Role of extension plant pathology in the present era

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Agricultural technology is constantly subjected to metamorphosis over years. Farmers are swamped with many new cultivars, pesticides, farm machines, farming techniques, new methods of disease and pest management. The plant disease epidemics cause major loss in food production worldwide. Totally 14.1 per cent of crops are lost due to plant disease alone and these losses are in part responsible for the suffering of 800 million people who lack adequate food. At this juncture, role of extension pathologist in disseminating the agriculture information through Information and Communication Technology (ICT) in the era of globalization, poses the best alternative means for a change in agriculture. Earlier extension work in Plant Pathology was undertaken in the context of fairs, farmer's institutes, short courses and so on. But in present era ICT is playing a major role in the progress of agriculture sector. "ICTs can be exploited to design cost effective systems to provide expert advice particularly to rural communities, helping to increase productivity and livelihoods". Types of ICT tools include radio, television, compact disc, mobile, internet data base, agri-portals, decision support system and expert system. The agriculture programmes on television and radio could hardly meet the information required by the farmers, affected with the compounding problems. With the use of cell phone the farmers who receive information through subject matter specialist are spreading the information to their fellow farmers and their foot falls along with other farmers to KVK have been significantly increased day by day for obtaining more information against a specific problem. The e-SAP model is an application of IT tool has helped for generating GIS maps ultimately to know the pest prone areas. It helps in disseminating the appropriate management practices to the farmers on real time basis and enables fast and deeper penetration of the information to the farmers. Even many agricultural apps are available for quick communication of agricultural technologies through mobile phones. As the new technologies are invented it has to be disseminated timely to the farmers. So there is an ample scope in strengthening of lab to land transfer. Research and extension must go hand by hand so that the end users are most benefited.

Technical Session VI

PGPR, bio-inoculants and its role in the management of diseases

Utilization of Endophytes in plant health management

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Endophytes are the microorganisms that reside inside healthy plant tissues without causing any detectable disease symptoms to the host. The term endophyte was introduced by Anton de Bary. Since the discovery of world's first billion dollar anticancer drug, Paclitaxel (Taxol) from *Pestalotiopsis microspora*, a fungus that colonizes the Himalayan yew tree, interest is growing in endophytes. The initiation of fungal endophytic associations inside roots can alter the mineral nutrient composition, the phytohormonal balance, and the chemical constituents of root exudates, and protect the plant against abiotic and biotic stresses. Endophytic fungi provide the host with an arsenal of metabolites that improve plant defenses against environmental stimuli. Recent studies demonstrated that endophytic fungi can produce phytohormones, especially gibberellins (GAs), to improve crop growth and mitigate the negative impacts of abiotic stresses. Because of their abilities to secrete bioactive metabolites, endophytic fungi can also reduce oxidative stress.

Natural compounds ranging from crop protection to human welfare have been isolated from this alternative source of endophytes. Several anticancer, antibiotic, antimycotic, antiviral, antioxidant, nematicide, insecticide and immunosuppressive compounds have been reported from endophytes. Many of them produce some toxic alkaloids and protect their hosts from herbivores. They also improve the growth and yield of crops under various stressed conditions. Endophytes are known to manage the plant diseases by induction of systemic resistance, antibiosis, hyperparasitism, predation, production of metabolites with nematicidal and insecticidal properties and occupation of ecological niche. Members of the Ascomycota, Basidiomycota and Deuteromycetes as well as some Oomycetes have been isolated as endophytes.

Dominant endophytic fungi are *Aspergillus* spp., *Phomopsis oblonga*, *Cladosporium cladosporioides*, *Acremonium* sp., *Absidia* and *Penicillium* sp. *In planta* studies indicated that preinoculation of rice plant with *Acremonium* sp. and *Absidia* were effective in preventing infection by *Magnaporthe grisea*. Application of endophytic fungus, *Penicillium citrinum* LWL 5 increased the seedling vigour and plant growth parameters in sunflower and reduced the effect of stem rot caused by *Sclerotium rolfsii*. Role of endophytes in plant disease management will be discussed in detail.

Efficacy of bio agents against *Cylindrosporium* leaf spot pathogen of *Nothapodytes nimmoniana* (an anti-cancer drug yielding tree) under *in vitro* conditions

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Cancer is one of the most deadly diseases in many countries. Most treatment plans may include surgery, radiation or chemotherapy. *Nothapodytes nimmoniana* is an important medicinal tree and well known source of the camptothecin (CPT), which is used in the treatment of cancer in traditional systems of medicine. Camptothecin (CPT), a monoterpeneindole alkaloid, is regarded as one of the most promising anticancer drug of the 21st century. However, incidence of fungal leaf spot disease caused by the pathogen *Cylindrosporium mappiae* has been reported to cause huge defoliation in *Nothapodytes nimmoniana*. Hence, the study was undertaken for the first time to evaluate the efficacy of various bioagents against the pathogen in laboratory conditions. Among the different fungal bio agents *Trichoderma harzianum*, IOF strain have exhibited maximum zone of inhibition (99.81%) followed by *Trichoderma viride* (89.97%) and found on par with *Trichoderma koengii* (88.59%). Among the bacterial antagonists *Pseudomonas fluorescens* and *Bacillus subtilis* (IOF strains) have shown growth inhibition of 70.74 per cent and 51.48 per cent respectively. Thus, biocontrol agents have a larger potential in managing the *cylindrosporium* leaf spot disease of *N. nimmoniana* which can be used as a component in integrated disease management.

Efficacy of *Bacillus subtilis* based bioformulation against bacterial blight of pomegranate

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Pomegranate is one of the most important cash crop of India and has gained worldwide importance due to its high nutritive and medicinal properties. Bacterial blight (BB) caused by *Xanthomonas axonopodis* pv. *punicae* (Xap) is one of the major constraints for pomegranate cultivation. Synthetic molecules use is a common practice for management against BB, which often pose constant threats of residual toxicity and safety issues among the consumers. Present study focused on understanding antagonistic activity of plant growth-promoting rhizobacteria *Bacillus subtilis*, development of effective liquid and powder based bio-formulation against BB of pomegranate and standardizing mass scale production protocol for farmer trial. The efficiency of oil based bioformulation was studied *in vitro* and in green house conditions against Xap. Under green house condition, oil based bioformulation was found more effective than powder based formulations, offering 76% protection over control. Expression analysis of different defense related genes such as PAL, catalase, CS3, PR1, PR3 and PR4 revealed that these defense related genes were upregulated upon treatment of *Bacillus subtilis* based liquid bioformulation at different time intervals.

Efficacy of botanicals against important phytopathogenic bacteria

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Bacterial diseases of plants are highly catastrophic and management is difficult. Use of chemicals are hazardous and hence, an alternate method of control needs to be developed which is effective, cheap and eco friendly. The plant extracts obtained from few medicinal plants were tested for their antibacterial effect against important plant pathogenic viz., *Ralstonia solanacearum*, *Xanthomonas axonopodis* pv. *vignicola* and *Xanthomonas campestris* pv. *campestris* causing bacterial wilt of tomato, cowpea bacterial blight and cabbage black rot respectively. The water extract from the two botanicals viz., *Ocimum gratissimum* and *Tylophora asthmatica* were effective in inhibiting the growth of *R. solanacearum*, *X. axonopodis* pv. *vignicola* and *X. campestris* pv. *campestris* upto 1:1 dilution. At 1:10 dilution water extract of *O. gratissimum* produced inhibition zones of 22.66, 21.66 and 22.33mm against *R. solanacearum*, *X. axonopodis* pv. *vignicola* and *X. campestris* pv. *campestris* respectively. Of the three bacteria tested, *R. solanacearum* was found to be more sensitive to *O. gratissimum* followed by *X. campestris* pv. *campestris* whereas, in cases of *T. asthmatica*, *X. campestris* pv. *campestris* was more sensitive followed by *X. axonopodis* pv. *vignicola* and *R. solanacearum*. Alcohol extract of *O. gratissimum* was effective against all the three bacteria tested upto 1:100 dilution, whereas, *O. sanctum* and *T. asthmatica* were effective upto 1:10 dilution. *Ruta graveolens* was effective upto 1:1 dilution against the three bacteria. In majority of cases *X. campestris* pv. *campestris* was most sensitive to the alcohol extracts followed by *X. axonopodis* pv. *vignicola* and *R. solanacearum* indicating that with the dilution of extract the inhibitory activity was lost.

Prevalence of postharvest diseases of banana and their biological management

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Market survey conducted in Hubballi and Dharwad for postharvest diseases of banana indicated that anthracnose caused by *Colletotrichum musae* and crown rot caused by *Fusarium semitectum* were predominant in both markets. Finger rot (*Lasiodiplodia theobromae*) and cigar end rot (*Verticillium theobromae*) were observed in traces. The mean disease incidence and severity of banana anthracnose was highest during rainy season in all the varieties and very less during summer. Crown rot was observed only during rainy season.

Consortium of three bioagents (*Bacillus subtilis* + *Pseudomonas fluorescens* + *Trichoderma harzianum*) effectively arrested the mycelial growth of both the pathogens; *C. musae* (89.26 %) and *F. semitectum* (93.41%). Among the botanicals, neemgold at 2.0 per cent effectively arrested the mycelial growth of *C. musae* (80.38%) and *F. semitectum* (75.82%). Out of five oils evaluated *in vitro*, complete inhibition of mycelial growth of *C. musae* was recorded in clove oil at 0.5 per cent and eucalyptus oil at 2.0 per cent concentration.

Among the bioagents tested *in vivo*, highest per cent disease reduction (82.86%) was noticed in consortium of three bioagents. Among the botanicals evaluated *in vivo*, maximum disease reduction (92.11 %) has been shown in fruits treated with neemgold and discheck at 2.0 per cent concentration which were found at par with nimbicidin at same concentration, neemgold and discheck at 1.0 per cent (89.47 %) as well as neemgold at 0.5 per cent (86.84 %). Out of the five oils, the most effective treatments were lemongrass oil at 2.0 and 1.0 per cent and neem oil at 2.0 per cent concentration which showed a disease reduction of 91.89 per cent. These were statistically on par with eucalyptus and neem oil at 2.0 per cent and neem oil at 1.0 per cent concentration (89.19 %).

Studies on compatibility of *Trichoderma viride* and *T. hamatum* with commonly used fungicides

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In the present day agriculture, the usage of pesticides has become an indispensable component. Since, the biocontrol agents are applied either to seed or soil or both, there is every possibility of interaction and interference that would arise with the commonly used agrochemicals applied to seed, soil or both. Compatibility study of living organisms with modern inputs in plant protection like fungicides is a pre-requisite for disease management and increasing plant growth. Hence, studied the compatibility seed treating and soil applicant fungicides with two efficient indigenous isolates viz., Tri-4 (*T. viride*) and Tri-12 (*T. hamatum*) against seven different fungicides. In case of *T. viride* the fungicides metalaxyl 75 % WP supported 100 per cent growth of mycelial at all the three concentrations, followed by pyraclostrobin 5 % + metiram 55 % WP supported 87.52 per cent at 0.05 per cent concentrations. In case of *T. hamatum* both metalaxyl 75 % WP and pyraclostrobin 5 % + metiram 55 % WP supported 100 per cent growth of mycelia at all the three concentrations, followed by thiram which inhibited growth at 28.89 per cent at 0.05 per cent concentration. Remaining fungicides viz., carboxin 37.5 % + thiram 37.5 % WP, hexaconazole 5 % + captan 70 % WP, propiconazole 25 % EC and tebuconazole 25.9 % EC inhibited the mycelial growth of two isolates of *Trichoderma* spp. more than 85 per cent at 0.05, 1 and 0.2 per cent concentration, hence they were not compatible with *Trichoderma* spp.

Biological control agents for the management of basal stem rot disease of coconut

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Coconut is primarily a small holder's crop with a recorded history of cultivation going back to more than 3000 years. It is now cultivated throughout the humid tropics. The crop is grown in homestead gardens as well as on plantation scale. Four southern states viz., Karnataka, Kerala, Tamil Nadu and Andhra Pradesh account for 90 per cent of coconut grown in India. In the recent past, the continuous occurrence of BSR in coconut has severely influenced adversely on the yield and on the existence of palms in various coconut gardens in Karnataka. In an effort to develop a sustainable management practice comprising of biological control agents, the soil borne microbes *Trichoderma*, and *Pseudomonas* were screened *in vitro* through dual culture method. Based on the results *Trichoderma reesei* and *Pseudomonas fluorescens* were found to be potent in arresting growth. Further, the field experiment for standardization of dosage frequency and method of application of *Trichoderma reesei* and *Pseudomonas fluorescens* was taken up at farmers holding in Gandsi, Arsikere taluk during second fortnight of June, 2014. A total of 12 treatments with three replications in different combinations were imposed. The results of the experiment clearly indicated at soil application of talc based formulation at 125 g each of *Trichoderma reesei* and *Pseudomonas fluorescens* along with 5 kg of neem cake per palm at yearly interval reduced the disease incidence and was significantly different from other treatments under study. In addition to this, the treatment could also increase the yield and other biometric parameters in coconut.

Evaluation of bio-fungicide taegro against sigatoka leaf spot disease in banana

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An experiment was conducted during 2014-2015 at K.R.C.College of Horticulture, Arabhavi, UHS, Bagalkot. Totally eight treatments viz.,untreated check, Propiconazole 0.1%, Stand alone (NZBBA1106WP) @0.37g/lit, Stand alone (NZBBA1106 WP) 0.74g/lit, Stand alone (NZBBA1106 WP) @1g/lit, propiconazole 0.1% alternate with NZBBA1106 WP @0.37g/lit, propiconazole 0.1% alternate with NZBBA1106 WP @0.74g/lit, propiconazole 0.1% alternate with NZBBA1106 1g/lit. Each treatment was replicated three times with a randomized block design . A susceptible cultivar Rajapuri (AAB) was planted with a spacing of 1.8X1.8m.

Results revealed that three sprays of propiconazole @ 0.1% alternate with three sprays of NZBBA1106 @ 1g/ lit effectively controlled the Sigatoka leaf spot disease (8.41%) followed by propiconazole @0.1%(9.32%), three sprays of propiconazole 0.1% alternate with three sprays of NZBBA1106 @ 0.74g/lit(11.98%), three sprays of propiconazole @ 0.1% alternate with three sprays of NZBBA1106 WP @ 0.37g/lit(15.47%) and NZBBA1106 WP @ 1g/lit(22.09%). The intensity of sigatoka leaf spot disease was highest in control (49.59%).

Research trends in biocontrol of plant pathogens by microorganisms between 1992 and 2016

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Bibliometric analysis is one of the methods to evaluate the potential areas of research in a given field; it provides a clear picture of evolution of a topic over a period of time. Therefore, bibliometric analysis was applied to reveal the research trends in the area of biological control of plant pathogens by microorganisms for the articles retrieved from science citation expanded index of web of science, as source of data collection. The “biocontrol” and “microorganism” were the keywords used to search in database for the time period of 1992-2016. A total of 890 research articles were published during this period and the literature was found to increase from year to year. The major contribution to the field of biocontrol research was from the USA (133 articles), followed by the Italy (75), China (690) and India (65). *Biological Control* (48 articles) was the most published journal on the topic followed by the *Biocontrol Science and Technology*. Shen QR from Nanjing Agricultural University, China had contributed highest number of articles to biocontrol research. The paper entitled “Antibiotic production by bacterial biocontrol agents” by Raajmakers *et al.*, (2002) was the most cited article (608 citations) that illustrates the antibiotics production in the spermosphere and rhizosphere of a variety of host plants and factors that influence antibiotic production by bacterial biocontrol agents.

Isolation and characterization of *Bacillus subtilis* from tomato rhizosphere soil

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Bacillus subtilis is a gram positive, motile, aerobic, rod shaped bacteria. The *B. subtilis* having Plant growth promoting rhizobacteria (PGPR) activity and helps in promoting the growth of plant and increasing quality and yield of crop. A roving survey was undertaken to assess the occurrence of *B. subtilis* in tomato crop in Haveri, Belgaum and Dharwad districts of northern Karnataka. Rhizosphere soil samples of tomato crop were collected and processed to isolate *B. subtilis*. Eight isolates were obtained and were identified through standard morphological and biochemical studies following Bergey's Manual of Determinative Bacteriology. With respect to morphological characters, all the *B. subtilis* isolates were gram positive and rod shaped and with respect to colony characters they were cream to white colored, circular to irregular shape and having irregular or ragged colony edge. Isolates BS-1, BS-4 and BS-6 had a colony character of cream color colonies, BS-2 and BS-6 having a colony characters of dull white colonies whereas, BS-3, BS-7 and BS-8 produced white colour colonies. All isolates except BS-5 and BS-6 were produced circular shape colonies where these two isolates produced irregular shape colonies. The results of the biochemical tests for identification of bioagents revealed that all the isolates showed positive reaction for starch hydrolysis, gelatin liquefaction, lipid hydrolysis, casein hydrolysis, VP test, citrate test, growth at 7.5 per cent NaCl, 5.7 pH condition and there was no growth of bioagent at 55°C temperature. Hence, all these isolates were confirmed as *B. subtilis*.

Effect of *Bacillus* spp. on growth parameter of tomato infected with nematode and bacterial wilt complex

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The experiment was made to study the effect of *Bacillus* spp. on growth and yield of tomato under protected cultivation. Following observations were taken into consideration viz., plant height, fresh and dry shoot, root length and fresh, dry root weight and yield/ plot over untreated control. The maximum fresh and dry shoot weight (217.12 and 88.07 g) was recorded in the *B. megaterium*- IIHR + *B. pumilus*- K-1 respectively, followed by carbofuran 3G (204.95 and 84.00 g) respectively. Maximum yield/plot was recorded in case of *B. megaterium*- IIHR + *B. pumilus*- K-1 (3.21 kg/plot) followed by streptomycin sulphate + COC (2.75 kg/ plot) respectively. All the treatments significantly reduced nematode population in soil over untreated control at harvest. However, *B. megaterium*- IIHR + *B. pumilus*- K-1, carbofuran 3G and carbofuran + streptomycin sulphate + COC were recorded 255.75, 269.25 and 277.25/ 200 cc soil respectively. Bacterial population was significantly reduced in case of *B. megaterium*- IIHR + *B. pumilus*- K-1 (2.50×10^3 cfu/g soil) followed by carbofuran and streptomycin sulphate + COC (2.25×10^4 cfu/g soil).

Evaluation of biocontrol agents against *Exserohilum turcicum* causing turcicum leaf blight of baby corn (*Zea mays* L.)

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The turcicum leaf blight is caused by *Exserohilum turcicum* and it is considered to be one of the most devastating diseases of baby corn, as it causes reduction in grain yield by 28 to 91 per cent. Hence, an attempt was made to evaluate different bio-agents against the pathogen under *in vitro* condition. The antagonistic activity of *Trichoderma harzianum*, *Bacillus subtilis* and *Pseudomonas fluorescense* against *Exserohilum turcicum* was evaluated. The results from *in vitro* analysis showed that *Trichoderma harzianum* was more efficient in inhibiting the mycelial growth of *Exserohilum turcicum* (68.10%) followed by *Bacillus subtilis* (63.66%) and *Pseudomonas fluorescense* (58.10 %). From the research results it may be concluded that *Trichoderma harzianum* possesses great potential as bio control agent against the turcicum leaf blight of baby corn, as it has more competitive ability in addition to antibiosis. *Pseudomonas* and *Bacillus* are also well known for their antagonistic effects and their ability to trigger induced systemic resistance.

Bacterial blight of pomegranate: Recent updates and perspectives of different management options

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Minimizing the global dependence on hazardous agricultural plant protectant chemicals threatening the agroecosystems is a very challenging for plant pathologists. The crop like pomegranate under the current scenario with ominous disease, bacterial blight caused by *Xanthomonas axonopodis* pv. *punicae* demands high cost-antibiotics and other synthetics having lethal repercussions on symbiotic microbial community, human and animal health. This paradigm context calls for the IDM integrating new generation defense inducers synergizing biological components for higher productivity sustaining soil health by replacing the antibiotic applications. Bacterial blight management approached with new generation molecules doesn't have antimicrobial property and able to systemically modulate plant hormone levels and defense signals decreasing the inhibitory effects of pathogens on fruit productivity of pomegranate. Defense inducers such as Trehalose, eugenol, laminarin, chitosan, salicylic acid, polaymaines, jasmonates and phenylpropanoids elicitors were identified to be used as potential components of the IDM and worked on discerning pathways for corroborating the basis of their use. Alternatively, plant hormones such as ethylene, auxins, gibberlins, jasmonates found balancing the immune responses of pomegranate against blight and participate in the developmental activities of the plant. Bioagents, such as *Trichoerma harzianum* as a potent candidate to stabilize the growth under heavy metals and other inhibitory synthetics; group of rhizobacteria for enhanced immunity and reproductive parameters were identified and formulated for ready use of the pomegranate farmers for the management of blight. The nutritional inputs and their pathophysiological role in alleviating the blight were identified and developed the package for the management of fruit cracking associated with blight disease of pomegranate.

Probiotic bacteria for the control of fumonisins associated with cereal grains and poultry feeds

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Fumonisin, being common in occurrence in maize-based feeds, pose a great threat to animal and human health. The present study is aimed at determining the antifungal activity of probiotic *Lactobacillus plantarum* MYS6 against a fumonisin producing fungus, *Fusarium* spp. Co-inoculation with the fungus revealed the inhibitory effect of *L. plantarum* MYS6 on fungal growth and biomass. Observation using scanning electron microscopy showed distortion of hyphal structures, swollen tips and disrupted conidia. Conidia germination inhibition assay restrained germination and showed deformed hyphae. Both the isolate and its extracellular metabolites lowered fumonisin content in feed model up to 0.505 mg/Kg of feed and 0.3125 mg/Kg of feed respectively when compared to the level of 0.870 mg/Kg of feed in control. Further, *in vivo* studies conducted to know probiotic effects treated with fumonisins. A dietary experiment of 42 days duration consisting of 64 broilers was performed in eight treatment groups. At the end of experiment, growth performance of broilers, hematology, serum biochemistry, and markers of oxidative stress were evaluated for each group and histopathology of hepatic and renal tissue was observed. The results demonstrated that *L. plantarum* MYS6 efficiently improved the feed intake, body weight and feed conversion ratio in FB1 intoxicated broilers. The probiotic strain mitigated the altered levels of hematological indices such as red blood cells count, hemoglobin, hematocrit, white blood cells count and platelet count. The probiotic also alleviated the levels of oxidative stress markers in serum and tissue homogenate of liver documenting its protective efficacy. Collectively, our study suggests the efficient protective role of *L. plantarum* MYS6 in ameliorating the FB1-induced toxicity in the vital organs and subsequent oxidative stress in broilers. Also, the probiotic strain could further be formulated into a functional feed owing to its beneficial health attributes.

***Bacillus* species with anti microbial peptide (amp) genes: unexplored treasure for the management of diseases in high valued horticulture crops**

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Floriculture is a persuasive field in trade with high potential returns per unit area. Because of this large number of farmers are attracted towards cut flower cultivation. Area under cut flower production is increasing constantly. Major cultivated crops include carnation, chrysanthemum, rose and liliium. These high valued cut flowers are highly susceptible to various diseases including, stem rot (*Sclerotinia sclerotiorum*), wilt (*Fusarium oxysporum* f.sp. *dianthi*), fairy ring spot (*Cladosporium echinulatum*), and blossom blight (*Botrytis cinerea*), white rust (*Puccinia horiana*), *Alternaria* leaf spot (*Alternaria* sp.), bacterial blight (*Erwinia chrysanthemi*) and crown gall (*Agrobacterium tumaeafaciens*). *Bacillus* species are widely exploited as biocontrol agents because of their efficiency in impeding various plant pathogens with their multifaceted approach. Well-exploited *Bacillus* species includes *B. subtilis*, *B. amyloliquefaciens*, *B. pumilus*, *B. methylotrophicus*, *B. licheniformis*, *B. megeeterium*, and *B. tequilensis*. *Bacillus* sp, handles an array of mode of actions against plant pathogens, including competition, secretion of siderophores, mycoparasitism, and induction of plant defense. However, antibiosis remains most influential among them. *Bacillus* species contain as many as 24 diverse AMP genes responsible for the biosynthesis of antibiotics like iturin, bacilysin, bacillomycin, fengycin, surfactin, mersacidin, ericin, subtilin, subtilosin and mycosubtilin. Antibiotics produced by the bacteria have specific modes of actions. Exposure to antimicrobial peptides results in immediate increases in water and ion flow, an efflux of K⁺ ions, swelling and osmotic dysregulation. Iturin at higher concentrations, lead to pore formation and solubilization of the pathogen cell membrane. Apart from anti microbial peptides, *Bacillus* sp is known to produce volatile and non-volatile antimicrobial compounds that synergistically aid in curtailing plant diseases.

B. amyloliquefaciens (VB7) was much effective in inhibiting mycelial growth of various pathogens *in vitro*. E-SEM analysis of the hyperparasitized sclerotial bodies of *S. sclerotiorum* revealed that the sclerotial walls were colonized and *B. amyloliquefaciens* (VB7), survived and multiplied in the cavities in the sclerotia. PCR detection of AMP genes revealed that *B. amyloliquefaciens* (VB7) had a maximum of 10 diverse antibiotic biosynthesis genes, namely, *ituD*, *ipa14*, *bacA*, *bacD*, *bamC*, *sfP*, *spaC*, *spaS*, *alba*, and *albF*, that resulted in production of the antibiotics iturin, bacilysin, bacillomycin, surfactin, subtilin and subtilosin. Further, metabolites from *B. amyloliquefaciens* (VB7), associated with inhibition of *S. sclerotiorum*, were identified as phenols and fatty acids by gas chromatography mass spectrometry (GC-MS), that includes chloroxylenol, pentadecenoicacid, heptadecenoicacid, octadecenoicacid, pyrrolo and hexadecenoicacid (Vinodkumar *et al.*, 2017).

Delivery of bacterial formulation of the effective strains of *Bacillus* spp. as root dip, soil drenching, foliar application was found promising for the management of various fungal diseases of horticultural crops. Delivering of *B. subtilis* (BS2) to carnation plants through root dipping and soil drenching @ 5ml/litre recorded only 1% *Fusarium* wilt incidence with flower yield of 244.80 numbers over an area of 1m² (Indumathi, 2012). Soil application of liquid formulation of *B. amyloliquefaciens* (VB7) - (2.5x10¹⁰cfu/ml) by root dip followed by soil drenching (5ml/l) at monthly intervals resulted in a minimal *Sclerotinia* rot incidence of 4.60%, which was reduced to 87.9% relative to the control. Studies on the yield parameters indicated that the mean shoot number (8.7 nos), stalk length (78.11 cm), and flower yield (234/m²) in the plants treated with *B. amyloliquefaciens* (VB7) were relatively higher than that of the untreated control. However, in untreated control 3.6 nos, 60 cm, 135/m² shoot number, stalk length and flower yield was observed (Vinodkumar *et al.*, 2017). Foliar application of *B. subtilis* (BS2) and *B. amyloliquefaciens* (BSC7) to chrysanthemum plants,

successfully controlled white rust (*Puccinia horriana*) up to 3.88 rust spots per leaf as against 26.79 white rust spots in untreated control (Dheepa *et al.*, 2016). In rose, foliar spray with *B. subtilis* (AP) and *B. amyloliquefaciens* (VB2) @ 0.5% four times at weekly intervals was effective in reducing *A. alternata* and *B. cinerea* intensity to an extent of 67% and 61.84% over control respectively. Comparison of yield parameters in terms of marketable blooms revealed that, 6,391.66 kgs/acre flowers was obtained in treated plot. However, in control the yield was comparatively lesser (3,735.58 kgs/acre) (Surya, 2016). Foliar spray with *B. amyloliquefaciens* VB7 (1% @ 10^8 CFU/ml) at fortnightly interval reduced PDI of *Botrytis* blight of 12.21 with the average yield of 41 stems/ m² over untreated control with 50.37 PDI and yield of 26 stems/ m². *B. amyloliquefaciens* (VB7) is an effective beneficial antagonist with multifaceted mode of action. The mode of action includes competitive colonization of rhizosphere, secretion of volatile and non-volatile anti fungal compounds as well anti microbial peptides. Soil application of the antagonists was effective in reducing the disease incidence as well promoted plant growth and yield. In this constraint, future studies in the exploitation of *Bacillus* species with diverse anti microbial peptide genes would be a scope for the management of various fungal and bacterial diseases in crop plants.

Prevalence of fluorescent pseudomonads in cruciferous rhizosphere, their characterization and severity of black rot of cabbage in northern Karnataka

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Cabbage (*Brassica oleraceae* var. *capitata* (L.)) is one of the most important vegetable crops cultivated extensively in tropical and temperate regions of the world. Cabbage is infected by many diseases. Among these, black rot of cabbage caused by *Xanthomonas campestris* pv. *campestris* is one of the most yield limiting and destructive pathogens of cruciferous crops worldwide. A random survey was conducted during *kharif* 2015 in cabbage growing areas of northern Karnataka revealed that severity of black rot of cabbage was observed in all district surveyed. The maximum disease index of 23.36 per cent was noticed in Belagavi district, followed by Dharwad (20.17 %) and the least disease index was observed in Haveri (18.65 %). The severity of black rot was highest at heading stage compared to vegetative stage. Prevalence of fluorescent pseudomonads was observed in all districts surveyed and wherever fluorescent pseudomonads were present in those locations the disease occurrence and severity was less compared to location where pseudomonads were absent. Eight fluorescent pseudomonads were identified based on their morphological characters, physiological and biochemical tests.

Isolation and characterization of endophytes associated with soybean in parts of northern Karnataka

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Plant biodiversity serves as a reservoir of plethora of microbes including endophytes, epiphytes and pathogens. Endophytes are known to colonize internal plant tissues without inducing apparent symptoms of the disease. Thus endophytes offer unique opportunity for crop protection and biological control. In this context, a roving survey was undertaken for the collection of healthy soybean plant samples during *kharif* 2017 at various locations of Belagavi, Haveri and Dharwad districts. Thirty healthy plant samples were collected across ten talukas of Belagavi, Haveri and Dharwad districts. The isolation of fungal and bacterial endophytes was taken up. Eleven fungal endophytes were isolated belonging to genera viz. *Aspergillus*, *Fusarium* etc. The fungal endophytes can be exploited further for the disease management in soybean.

Antagonistic activity of endophytic bacterial flora isolated from different varieties of mango against *Colletotrichum gloeosporioides*(Penz.) causing anthracnose of mango

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Mango is attacked by many diseases among which mango anthracnose caused by *Colletotrichum gloeosporioides* (Penz.) is an important and most severe disease of field and post-harvest. In the present study, we aimed to isolate endophytes from different mango varieties and test their antagonistic activity against the pathogen. Endophytes are the microbes that colonize within the healthy tissue of plant. Endophytic bacteria were isolated from mango varieties viz., Alphonso, Totapuri, Neelam, Anfas, Willard, Badam Model, Khaderi, Pancharasi, White Sari and Kisan Bhog. Twenty endophytic bacterial isolates were isolated from ten mango varieties *i. e.*, ten endophytic bacteria from each leaf and stem sample. For characterization of isolated endophytic bacteria, different biochemical tests like indole test, methyl red, voges proskauer and citrate utilization tests were carried out and the results showed that all the bacterial endophytes were negative for indole test and all endophytes except EBPL-1 and EBWDS-1 were negative for MR test. All endophytes except EBPL-1 and EBWDS-1 were positive for VP test. Similarly all endophytes except EBPL-1 and EBWDS-1 showed positive result for citrate utilization test. Among all the endophytic bacterial isolates isolated from different mango varieties EBANL-1 isolated from the leaf tissue of Anfas showed maximum inhibition of 56.67% followed by EBPS-1 (55.48%) isolated from the stem tissue of Pancharasi against *Colletotrichum gloeosporioides* (Penz.).

Antagonistic activity of endophytic bacterial flora isolated from different varieties of mango against *Colletotrichum gloeosporioides*(Penz.) causing anthracnose of mango

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Mango is attacked by many diseases among which mango anthracnose caused by *Colletotrichum gloeosporioides* (Penz.) is an important and most severe disease of field and post-harvest. In the present study, we aimed to isolate endophytes from different mango varieties and test their antagonistic activity against the pathogen. Endophytes are the microbes that colonize within the healthy tissue of plant. Endophytic bacteria were isolated from mango varieties viz., Alphonso, Totapuri, Neelam, Anfas, Willard, Badam Model, Khaderi, Pancharasi, White Sari and Kisan Bhog. Twenty endophytic bacterial isolates were isolated from ten mango varieties *i. e.*, ten endophytic bacteria from each leaf and stem sample. For characterization of isolated endophytic bacteria, different biochemical tests like indole test, methyl red, voges proskauer and citrate utilization tests were carried out and the results showed that all the bacterial endophytes were negative for indole test and all endophytes except EBPL-1 and EBWDS-1 were negative for MR test. All endophytes except EBPL-1 and EBWDS-1 were positive for VP test. Similarly all endophytes except EBPL-1 and EBWDS-1 showed positive result for citrate utilization test. Among all the endophytic bacterial isolates isolated from different mango varieties EBANL-1 isolated from the leaf tissue of Anfas showed maximum inhibition of 56.67% followed by EBPS-1 (55.48%) isolated from the stem tissue of Pancharasi against *Colletotrichum gloeosporioides* (Penz.).

Formulation, shelf life and compatibility of *Bacillus subtilis* (BS16) with fungicides in chilli ecosystem

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Rhizosphere bacteria are one of the most potential biocontrol agents in plant disease management. Among them, *Bacillus subtilis* have advantages over other bacteria because of their ability to form endospore and broad spectrum antibiotic activities. Once the potential bioagents are identified, the application and delivery of bioagents is essential to carry them to a logical conclusion to farmer's field. Hence, the formulation of bioagent is a priority. The superior isolate identified on basis of bioefficacy, *B. subtilis* (BS16) was formulated in various carriers and stored at room temperature to study the shelf life. The population of *B. subtilis* (BS16) was significantly higher in talc powder (1.8×10^8 cfu/g) followed by vermicompost (1.7×10^8 cfu/g) and least was in case of rice bran+husk (1.1×10^8 cfu/g) compared to other carrier materials. Therefore, the talc powder is considered to be best suited carrier material for long time storage. The bioagent alone will not be lasting solution for management of diseases of any crops. Crops in general are infected by several pathogens of fungi, bacteria, nematodes etc. In other words, in an ecosystem the bioagent can well be integrated with IPM inputs, hence its compatibility with other bioagent is called for. The formulated isolate was studied for compatibility with six fungicides at four different concentrations, Among six fungicides, carbendazim 50 WP showed least zone of inhibition (15.03 mm) at 0.3 % and tricyclazole 18 % + mancozeb 62 % WP showed highest zone of inhibition (23.13 mm) at 0.3 %. It is concluded that carbendazim 50 WP is more compatible with *B. subtilis* compared to others fungicides.

Induction of systemic resistance in chilli using *Bacillus subtilis* (Cohn) isolates against *Fusarium* wilt

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Bacillus subtilis (Cohn) is one of the most potential biocontrol agents in plant disease management. It has many mechanisms viz., formation of endospore, antibiosis, competition, mycoparasitism and induced systemic resistance in host plant which makes it an ideal bio control agent. Thirty isolates were collected from rhizosphere soil samples from different parts of north eastern Karnataka. *B. subtilis* plays a major role in plant growth promotion and biocontrol of pathogens through ISR. The bioagent *B. subtilis* isolates were studied under *in vitro* conditions by challenge inoculation with wilt causing pathogen of chilli (*Fusarium solani*). The *B. subtilis* isolate BS 16 recorded highest (94.25 %) seed germination, vigour index (1030), shoot length (8.50 cm) and root length (4.8 cm) and least seed germination was 40 per cent with vigour index of 267, mean shoot length of 3.8 cm and mean root length of 3.00 cm in case of *F. solani* alone. The treatment BS16+FS recorded higher PO (1.04 change in absorbance at 470 nm/min/mg protein), PPO (0.79 change in absorbance at 420 nm/min/mg protein) and PAL (80.45 nmol trans-cinamic acid/hr/mg protein) activity on the 7th day after challenge inoculation, thereafter the activity declined by 9th day. Least PO activity was noticed in uninoculated plants (0.65 change in absorbance at 470 nm/min/mg protein), PPO (0.40 change in absorbance at 420 nm/min/mg protein) and PAL (50.42 nmol trans-cinamic acid/hr/mg protein). All the isolates have the ability to induce the systemic resistance by increase in the PO activity.

Optimization of an anti hyperglycemic polyherbal formulation using response surface methodology

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The present study was aimed to optimize the concentrations of methanolic seed extracts of *Salvia hispanica*, *Quinoa chenopodium* and *Nelumbo nucifera* for the development of an anti-hyperglycemic polyherbal formulation with multifunctional potentials based on response surface methodology using central composite design. A three-level factorial design was applied to determine the combined effect of three independent variables (*S. hispanica*: X₁; *C. quinoa*: X₂ and *N. nucifera*: X₃) on inhibition of four response variables (Q⁻ amylase: Y₁; Q⁻ glucosidase: Y₂; DPPH: Y₃ and Lipase: Y₄). The three factors were coded at five levels i.e. -1, 0, +1 and +2, which resulted in an experimental design of 20 runs. The optimum concentration of all the combinations was found to be 1 mg/ml which showed α-amylase (79.51%), α-glucosidase (82.97%) and lipase (70.47%) inhibitory activities with DPPH scavenging potential (83.47%). A quadratic polynomial equation was found to best fit the model with α-amylase R² = 0.891, α-glucosidase R² = 0.911, DPPH R² = 0.904 and lipase R² = 0.915. The F values for lack-of-fit were not significant (p > 0.05) for all four second-order equation, indicating them to be appropriate for describing the response surface model. The analytical method was validated and it was observed that the obtained experimental results for optimized formulation were slightly higher compared to the predicted values and also the optimized formulation gave good α-amylase (80.07%), α-glucosidase (82.74%) and lipase (70.94%) inhibitory activities with DPPH scavenging potential (84.21%) compared to other 19 formulations. Therefore the above combination of three seed extracts with 1mg/ml concentration was chosen further to develop polyherbal antihyperglycemic formulation.

Bioagents and signaling molecules liquid consortium as bio-priming in enhancing seedling vigour in Byadgi chilli

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Seed treatment is considered as effective and efficient treatment in controlling seed borne and soil borne diseases at initial crop growth stage. However, application of poisonous chemicals for seeds may have negative effect on seedling vigour resulting in production of abnormal seedlings. Byadgi chilli are commercially grown by drill sowing of seeds and rarely raising seedlings in portrays and later planting in the main field. Seedlings of chilli are easily affected by seed borne and damping off diseases during seedling stage resulting in production of poor vigour seedlings. Bioagents are known for decreasing the incidence of diseases and also enhancing the plant growth. The signaling molecules also have positive effect in controlling the diseases in many crops. Biopriming is considered as pre-sowing treatment to enhance the seedling vigour under biotic stress. A liquid consortium was developed consisting of bioagents viz., *Trichoderma* and *Pseudomonas*; signaling molecules viz., chitosan and clove oil. Initially liquid consortium was experimented at different CFUs and concentrations of signaling molecules and finally an effective formulations was developed for bio-priming of seeds. One year old seeds of Chilli var. Byadgi dabbi was bioprimed with the final concentration of consortium for 12 hrs before sowing in portrays. The results revealed that biopriming has significantly reduced incidence of diseases and enhanced germination (91 %) and transplantable seedlings (91 %) compared to untreated seeds (83 % and 81 %, respectively). The consortium has also increased the seedling length (19.57 cm), root length (7.37 cm) and seedling vigour index (3070) over control (16.26 cm, 5.04 cm and 1578 respectively)

Evaluation of *Bacillus* spp. on root knot nematode and bacterial wilt complex of tomato under protected cultivation

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An attempt was made to study the efficacy of *Bacillus* spp. for the management of nematode and bacterial wilt complex in tomato under protected condition. The studies indicated that, *Bacillus pumilus*-K-1 and *B. megaterium*-IIHR in combination were found to be effective for the management of nematode bacterial wilt complex with 29.18 per cent wilt incidence over untreated control (82.85%). However, least wilt incidence of 12.50 per cent was observed in streptomycin sulphate. *B. pumilus*-K-1 and *B. megaterium*-IIHR treated plants recorded significantly less number of galls per root system (94.00), number of egg masses per root system (40.50) and number of eggs per egg mass (105.50) over untreated control (195.75, 100.50 and 238.50) respectively.

Screening of different media and growth conditions for bacterial bio-agents effective against *Xanthomonas axonopodis* pv. *punicae* causing blight in pomegranate

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The optimum growth condition (medium, temperature, pH) for the four bacterial bio-control agents viz., *Bacillus subtilis*-KK-9A, *Brevibacillus borstelensis*-BK-6, *Brevibacillus* sp-PM-2A and *Lysinibacillus xylanilyticus*-VK-6B which were found effective against *Xanthomonas axonopodis* pv. *punicae* causing blight in pomegranate were identified. Eight semi selective media AK agar No.2, King's B, LB agar, maintenance medium, nutrient agar, nutrient glucose agar, nutrient sucrose agar and nutrient agar w/ s magnesium were tested, it was observed that, out of eight different media tested for growth of all the four bioagents, the medium AK agar No.2 supported all the four bioagents to get highest mean number of colonies (129.80) followed by maintenance medium (127.80), LB agar (94.30), nutrient agar (90.70), King's B (62.50), nutrient agar w/s magnesium (43.30), nutrient glucose agar (52.0) and nutrient sucrose agar (32.90). The temperature range from 10–40°C and pH range from 4-10 was determined using spectrophotometer and turbidity values at 600 nm. The results revealed that the temperature of 30 °C and pH 7 was found optimum for the maximum growth of bacterial antagonists viz., *Brevibacillus borstelensis*, *Brevibacillus* sp, *Lysinibacillus xylanilyticus*. Whereas, *Bacillus subtilis* required 35 °C and pH of 7 for its maximum growth. Eight semi selective media, different temperatures and pH were tested in order to find out the efficient medium and growth conditions for the maximal growth of all the four bacterial bio-agents by spread plate method. The media viz., nutrient agar, King's B, nutrient sucrose agar, nutrient glucose agar, maintenance medium, LB agar, AK agar No.2 and nutrient agar w/ s magnesium were used in the study. During this study, it was observed that, out of eight different media tested for growth of *Bacillus subtilis*-KK-9A, *Brevibacillus borstelensis*-BK-6, *Brevibacillus* sp-PM-2A and *Lysinibacillus xylanilyticus*-VK-6B, the medium AK agar No.2 supported all the four bio-agents to get highest mean number of colonies (129.80) followed by maintenance medium (127.80), LB agar (94.30), nutrient agar (90.70), King's B (62.50), nutrient agar v/s magnesium (43.30), nutrient glucose agar (52.0) and nutrient sucrose agar (32.90). The temperature range from 10–40°C and pH range from 4-10 was determined using spectrophotometer and turbidity values were recorded at 600 nm. The results revealed that the temperature of 30°C and pH 7 was found optimum for the maximum growth of bacterial antagonists viz., *Brevibacillus borstelensis*, *Brevibacillus* sp, *Lysinibacillus xylanilyticus*. Whereas, *Bacillus subtilis* required 35°C and pH of 7 for its maximum growth.

Ex situ planting material –a challenge to biosecurity and plant health and role of GAP and soil antagonistic potential in promotion of soil and plant health

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The enterprise of plant nursery and *ex situ* planting material in the country and across the globe over years, has now attained the status of an industry of international fame. Plant nursery production-supply chain is now a multi-billion rupee/dollars industry providing livelihood, employment, profitability and also self-sustenance and catering to the needs of farmer, forestry, socio-political-urban forestry and supply chain of healthy stock of planting material across the country and regions. Significantly, about 3000-5000 truckloads of plant consignments are traded a day from the Godavari river banks alone in India. More than 200 plant species and their varieties belonging to fruits, floriculture, ornamentals, indoor-ornamentals, cacti, avenue and forest flora are traded. However, the plant industry and plant health in fields are seriously threatened by major soil-borne biotic limiting factors *viz.*, root-knot nematodes, pathogenic fungi of Oomycetes and wilt bacteria. Pathogenic fungi of Oomycetes and wilt bacteria are being managed with integrated use of biocontrol agents, *Trichoderma*, *Pseudomonas* etc., and fungicides. Spread of obnoxious nematode infection/infestation to areas not known for root-knot nematode menace, through movement of planting material and soils have become serious biosecurity issues besides a loss of planting material recorded to the tune of 28-42% in different nurseries and different crops and nematode infestation to the tune of 48-72% of farm areas. Several chemicals including carbofuran, phorate, chlorpyrifos, etc., are being used indiscriminately causing not only loss to soil biota but also water body pollution in these regions. We report the necessity and impact of a combination of Good Agricultural Practices including raising of nurseries in healthy soils, soilless cultivation, demarcation and exclusion of soils where nematode infection has been recorded, use of grafting on resistant-root stocks, Crop hygiene and clean cultivation, transport, along with promotion of antagonistic potential of soils and rooting media with beneficial antagonistic fungi *viz.*, *Pochonia chlamydosporia* and *Paecilomyces lilacinus* at plant multiplication, packaging and planting on ensuring biosecurity, plant health, productivity and livelihood. The major constraints and gaps in adoption of these GAPs are also discussed.

Comparative growth studies of *Trichoderma* species on different cultural media's

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Disease refers to abnormality in the normal life process of the plant. No single control strategy could provide an adequate level in control of disease infestation. Chronic conditions account for more than 50 per cent of crop loss. Integrated disease management (IDM) is an innovative concept by which care is delivered in a better coordinated way through the integration of several components; such as Physical, chemical, cultural and biological methods. Bio-inoculants are a natural products carrying living microorganisms derived from the root or cultivated soil. Many of the microbes involved in symbiotic relationships with the target crops where both parties are benefited. Among them, *Trichoderma spp.* is most preferred biocontrol for several plant pathogens. Investigation was carried out to determine the growth of *Trichoderma spp.* on different media, potato dextrose agar (PDA), rose bengal agar, Saubouraud media, and Czephaks media at 27±1°C. Inoculants were elucidated by serial dilution method from the soils collected from different plantations of Karnataka state. The radial growth of the fungi were recorded, when the maximum mycelial growth of fungi attained in any one of the media's. Maximum mycelial growth of 44 mm was observed in PDA followed by sabouraud's agar, 39.3 mm, while poor growth was observed in Czephak's media, 20 mm. Hence, PDA is found to be a best growth media for *Trichoderma* culturing.

Study on efficacy of bioagents on green gram seed borne fungi

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Green gram yields are remarkably low due to various factors of biotic and abiotic nature which take a heavy toll of the crop, of which diseases account for an estimated yield loss of 20-30 per cent . Among various diseases on green gram anthracnose results in a yield loss of 18.2-86.5 per cent. Hence, to test the efficacy of fungal and bacterial antagonistic formulations were controlling the seed borne fungi in seed samples of green gram collected from northern Karnataka were used for laboratory test. Seed treatment with talc based formulation of *Trichoderma viride*, *Trichoderma harzianum* *Pseudomonas fluorescens* and *Bacillus subtilis* at 0.4 per cent and 0.8 per cent respectively. Bioagents were tested for their efficacy against seed-borne mycoflora to improve seed germination and also recorded significantly incidence of seed borne fungi. Among this, four bioagents *T. harzianum* showed the least seed infection (17.00%), higher per cent germination (79.50%) and high vigour index (1432.20) and it was significantly superior over seed treatment with *T. viride*, *P. fluorescens* and *B. subtilis* treatments. Seed treatment with 0.8 per cent concentration of *T. harzianum* exhibited seed infection of 15.67 per cent, seed germination of 82.67 per cent and vigour index of 1510.40 which is found to be statistically significant from *T. harzianum* seed treatment at 0.4 per cent concentration, which exhibited seed infection of 18.33 per cent, seed germination of 76.33 per cent and vigour index of 1354.00. Seed treatment with *B. subtilis* was found ineffective recording 22.00 per cent of seed infection, with 73.83 per cent of germination and 1054.78 of vigour index.

Shelf-life and bioefficacy of liquid inoculant formulations of *Pseudomonas fluorescens*

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The present study aimed at formulating, study of shelf-life and evaluating the bioefficacy of liquid inoculant formulation of *Pseudomonas fluorescens* developed with the use of polymeric additives. The liquid inoculant formulations of *Pseudomonas fluorescens* were prepared using the polymeric additives in varying combinations and the formulated liquid inoculants were assessed for their shelf-life at monthly intervals and were evaluated for their bioefficacy against the *Fusarium* (*Fusarium oxysporum* f. sp. *lycopersici*) wilt of tomato under greenhouse conditions. Polymeric additives used were cell protectants viz., polyvinylpyrrolidone (PVP, 2%), polyethylene glycol (PEG, 1%), gum arabic (0.8%) and sodium alginate (0.1%); adjuvants viz., xanthan gum (0.3%) and carboxymethyl cellulose (CMC, 0.1%); surfactant used was Tween-20 (0.5%) and preservative was potassium sorbate (0.2%). LIF (Liquid inoculant formulation) prepared using PVP as cell protectant and xanthan gum as adjuvant along with tween-20 and potassium sorbate as surfactant and preservative respectively retained 1.76×10^{10} CFU/ml upto 180 days of storage. The tomato seedlings treated with the LIF showed best results in all the growth and yield parameters studied and even the disease incidence was the lowest in these plants. The formulated liquid inoculants were found to have enhanced shelf-life and improved viability.

Liquid inoculant formulations of *Pseudomonas fluorescens* using cell protectants, adjuvants, surfactant and preservative

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Liquid inoculant formulations of *Pseudomonas fluorescens* were developed using cell protectants viz., polyvinylpyrrolidone (PVP, 2%), polyethylene glycol (PEG, 1%), gum arabic (0.8%) and sodium alginate (0.1%). Adjuvants used were xanthan gum (0.3%) and carboxymethyl cellulose (CMC, 0.1%). Tween 20 (0.5%) was used as a surfactant and potassium sorbate (0.2%) as a preservative. These liquid inoculants were stored in BOD incubator at 28 ± 2 °C for a period of 180 days. Liquid inoculant formulation produced using cell protectant, polyvinylpyrrolidone (2%), adjuvant xanthan gum (0.3%), Tween 20 (0.5%) as surfactant and potassium sorbate (0.2%) as preservative retained 1.76×10^{10} CFU/ml at the end of 180 days of storage. Further, these formulated liquid inoculants were found to have enhanced shelf-life with promise in extended viability.

Evaluation of indigenous fluorescent *Pseudomonas* for the management of newly emerging wilt of pomegranate caused by *Ceratocystis fimbriata*

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Pomegranate (*Punica granatum*L.) is an economically important and vital cash crop of India. Wilt caused by *Ceratocystis fimbriata* Elli. and Halst. is a new devastating disease on pomegranate caused losses estimated up to 30% and becoming a major threat leading to destruction of several pomegranate orchards. Although, suitable wilt management practices include cultural, sanitation, and chemical have been developed, there is still a need to develop more economical, feasible and effective environmentally-friendly alternative control methods. In recent years, there has been an increased interest in the search of plant growth-promoting rhizobacteria (PGPR) for sustainable crop production. Thus, the present study was aimed in screening of indigenous PGPR isolates with multiple traits related to biocontrol and growth promotion. In this study, 33 isolates of fluorescent *Pseudomonads* were isolated from the rhizosphere soil of wilt affected pomegranate orchards and further screened for their antagonistic activity against *C. fimbriata*. Among 33 isolates, 11 isolates (PFP1 - PFP11) significantly reduced the mycelial growth of *C. Fimbriata* and these isolates were characterized morphologically and biochemically. These isolates showed positive response for plant growth promoting traits such as production of indole acetic acid (IAA), hydrogen cyanide (HCN), Hydrogen sulphide and siderophore. Two isolates PFP-11 and PFP-10 showed remarkable antifungal activity against *C. fimbriata* with the inhibition of 72.04% and 71.20%, respectively. These isolates showed significant producers of HCN, IAA and siderophore. This study suggest that these fluorescent *Pseudomonads* isolates can be developed as potential commercial biocontrol agents for sustainable management of newly emerging wilt disease of pomegranate caused by *C. fimbriata*.

Biochemical characterization of Gram positive bacterial microbiota of vanilla and its evaluation against *Fusarium oxysporum* f.sp. *vanilla*

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Vanilla (*Vanilla planifolia*) is one of the most important spice crops often referred as “Prince of spices” grown in Western Ghats owing to its high international market value. Vanilla cultivation is severely hampered by the many fungal diseases. One of the most important is root and stem rot caused by *Fusarium oxysporum* f.sp. *vanillae* (Fov). During the year 2016-2017, a survey was conducted in major vanilla growing states of south India for recording the incidence of wilt disease, the wilt incidence ranged from 0-25% and maximum incidence of wilt was in Madikeri taluk of Coorg district with 25 % disease incidence followed by Sirsi. Bacterial microbes were collected from all parts of Vanilla plant which were free from diseases collected from infected gardens. A total of 32 isolates of bacteria were isolated from roots, stems, leaves and characterized by biochemical methods. Among the 32 isolates, 14 isolates belonged to *Bacillus subtilis*, nine to *B. cereus*, three to *B. pumilis*, two to *B. thuringensis* and *B. coagulans* and one to *B. atrophaeus* and one unidentified. All the bacterial isolates were screened against Fov, under *in vitro* by dual culture method, maximum reduction of pathogen about 53.33 % was recorded in VREn1 followed by VLEn2 with 50.66 % reduction over control. Thus from the initial evaluation few promising isolates are characterized and further evaluated under glasshouse conditions.

Technical Session VII

Bio and Nano technological approaches in plant disease management

Nanotechnology: A new technology in plant disease management

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Every year 20-30 % crop yield loss is because of the pathogen attack. The research exploring nanotechnology as new source for improvement of agricultural sector. Nano particles can potentially used in the pathogen diagnosis and plant protection. When plant affected by pathogens nano particles may act upon pathogens in a way similar to chemical fungicide. The size of the nano particles (1-100 nm) have greater benefit in plant protection against the diseases. Silver nano particles (NPs) inhibits the colonization of pathogens. Antibacterial activities of Zn, Cu and Ag NPs against *P. aeruginosa*. CuSO_4 and $\text{Na}_2\text{B}_4\text{O}_7$ were found most effective in control of rust disease. Mg and Zn suppresses the damping off and charcoal rot disease.

Timely and slow release of chemical shall reduce the net amount of fungicide required for disease control. This can achieved by nanotechnology. Nano particles decrease the amount of fungicide input. It also reduces the rate of application because quantity required for application is at least 10 times lesser than the normal fungicides. Due to kinetics stability, smaller size, low viscosity and optical transparency nano emulsions can serve as a better pesticide delivery systems. Nano pesticides can increases the dispersion and wettability of agricultural formulation. Due to large specific surface area nano particles increased affinity to the target.

Molecular variability of groundnut bud necrosis virus causing bud blight in tomato

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The molecular variability studies were undertaken for the bud blight disease caused by *Ground nut bud necrosis virus* (GBNV) in major tomato growing regions of Dharwad, Belgaum, Haveri, Kolar and Bengaluru rural. Results revealed that the cloned DNA fragment of 831 bp long nucleotide sequence in all five isolates. The sequence similarity index obtained in Bio-Edit software revealed the reported GBNV- To- DWD coat protein gene sequence had 96.0 per cent homology with GBNV-To-BGM, 99.2 per cent homology with GBNV- To- HVR, 94.9 per cent homology with GBNV- To-KLR and 94.8 per cent homology with GBNV-To-BAN-R isolates. Highest homology of 99.2 per cent was found between CP gene sequences of GBNV To- DWD and GBNV- To- HVR followed by 96.1 per cent between GBNV-To- BGM and GBNV-To-BAN-R. The phylogenetic relationship of GBNV isolates from different hosts available in GenBank including five from the present study and tospoviruses of the same serogroup were studied based on nucleotide sequences of the CP gene. The results showed segregation of all the GBNV isolates into three clusters. Cluster I had all the GBNV isolates including all the five isolates of the present study (There was no correlation between the variations in the sequences of GBNV isolates either with geographical locations or with hosts) and the cluster II consisted the other tospovirus *Watermelon bud necrosis virus* (WBNV), whereas, *Capsicum chlorosis virus* (CaCV), *Watermelon silver mottle virus* and *Calla lily chlorotic spot virus* (CCSV) formed a separate cluster.

Molecular characterization of lima bean (*Phaseolus lunatus* L.) phyllody phytoplasma

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Lima bean (*Phaseolus lunatus* L.) is the second most important legume species of *Phaseolus* genus and is one of the 12 primary grain legumes belonging to the family Fabaceae. It is used both as a vegetable and pulse crop and is commonly known as Double bean, Sieve bean, Butter bean, Madagascar bean, Sugar bean and Towe bean. Phyllody disease in Lima bean caused by Phytoplasma has been gaining importance in the recent years. Phyllody infected plants were characterized by excessive branching, reduced plant height, leaf size and transformation of floral structures in to leaf-like structures that lead to sterility. In the present investigation, polymerase chain reaction (PCR) using primers P1/P7 and R16F2n/R16R2 corresponding to 16srDNA region of Phytoplasma was employed to detect the phytoplasma associated with lima bean phyllody. Phytoplasma specific products of 1800 and 1250bp were obtained from phyllody affected lima bean plants with primer pairs P1/P7 and R16F2n/R16R2 respectively. Efforts were also made to characterize the phytoplasma by sequencing 16SrDNA region of lima bean phyllody Phytoplasma and the results indicated that Phytoplasma associated with Lima bean phyllody disease showed 97% identity with Chickpea phyllody phytoplasma (ACCESSION KX151124) from Kanpur, Phylogenetic analysis of 16s rDNA region revealed that phytoplasma infecting lima bean belongs to 16SrII (Peanut WB group).

Studies on morphological and molecular variability of the pathogen

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Alternaria brassicicola and *A. brassicae* cause leaf spot of cultivated and wild crucifers. *Alternaria* leaf spot is one of the most widely present diseases next to the black rot of cabbage in northern parts of Karnataka. So the effort was made to study the morphological and molecular variability of the pathogen. The pathogens (*A. brassicae* and *A. brassicicola*) were isolated from cabbage leaves showing typical symptoms. The fungus was grown on PDA, it produced dark brown to black mycelium, brown to olvaceous brown conidiophores, with conidia having typical transverse and longitudinal septa with beak. Nine isolates were collected from different districts and maximum length and thickness of conidia was observed in Galaganath isolate (80-102 X 18-23 μ m) and minimum length and breadth of conidia were observed in Dharwad isolate (44-73 X 13- 22 μ m). Longest beak was observed in Galaganath isolate (13-18 μ m) and minimum length of beak was observed in Arabhavi isolate (7 -11 μ m). Beak width was more in Galaganath isolate (8 - 14 μ m) and it was least in Dharwad isolate (6 - 10). Maximum number of horizontal septa were found in Galaganath isolate (3-6 μ) and least number of horizontal septa were observed in Dharwad isolate (2-3). Highest number of vertical septa were found in Saundatti and Galaganath isolate (0-2) and less number of vertical septa were recorded in Kalagatagi and Guddada Channapur isolate (0-1) and in molecular aspect all the isolates were amplified at 590bp and the NCBI blast results confirmed that all four tested isolates were *Alternaria brassicicola*.

Nanotechnology: scope and application in plant disease management

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Nanotechnology is one of the most fascinating and rapidly advancing sciences and possesses potential to revolutionize many disciplines of science, technology, medicine and agriculture. In agriculture, nanotechnology has potential scope for natural resource exploitation, conservation and production and protection of crop and livestock. The subject nanotechnology deals with manufacturing, study and manipulation of matter at nano-scale (or atomic scale) in the size range of 1-100 nm which may be called as nanoparticles. It has major two aspects, the first aspect is synthesis of nano-size materials and second the application of nano materials for specific objectives. They can be produced by chemical, physical and biological methods. Nanomaterials can be potentially used in the plant disease management aspects concerning fungi, bacteria and flowering plant parasite by developing nanoparticles of different metals, pesticides and growth promoters. E.g. nanosized silver, nanosized silica-silver, mesoporous silica nanoparticle, nano-copper and Nano-iron. Nanoparticles may act upon pathogens in a similar way to chemical pesticides or they can be used as carrier of active ingredients of pesticides, host defence inducing chemicals etc., to the target pathogens. Disease diagnosis, pathogen detection and residual analysis may become more precise and quick with the use of nanosensors.

Nanotechnology novel tool for diagnosis and management of plant disease

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Climate change is one of the potential factors for adaptation and development of virulent races in plant pathogens. In recent past nanotechnology is more influencing the several research areas of agricultural and allied fields, including plant pathology. Detection of plant pathogens or the races at early stages is very important. Fluorescent silica nanoparticles (FSNPs) combined with antibody as a biomarker was successful in detecting the *Xanthomonas axonopodis* pv. *vesicatoria*. Gold nanoparticle-based optical immunosensors have been developed for detection of karnal bunt of wheat. Quantum Dot Fluorescent Resonance Energy Transfer (QD-FRET) based sensors for plant diseases detection such as the witches broom disease of lime (WBDL) caused by *Candidatus Phytoplasma aurantifolia* and QD-FRET was also reported to detect the disease vectors. Nano-silica/gold conjugated with probes used for detection of mycotoxins. Biopolymer encapsulated silver nano substrate, micro fluid bio sensor and quantum dots used for detection of food borne pathogens (*Salmonella typhimurium*, *E. coli* and *Staphylococcus aureus*). Targeted management of plant disease with lower dose nano formulations is newly emphasizing analogous to target delivery in medical sciences. Silver, copper, sulphur, zinc nanoparticles were synthesized by plant/chitosan mediated green nanotechnology. Nanoparticles were confirmed by particle size analyzer and atomic force microscope. Confirmed nanoparticles were tested against plant pathogens viz., *Xanthomonas* spp. *Ralstonia solanacearum*, *Sclerotium rolfsii*, *Rhiztonia solani*, *Colletotrichum truncatum* and *Bipolaris sorokiniana*. AgNPs synthesized from wild brinjal (*Solanum toruvm*) showed no phytotoxicity up to 2 ppm. Further, these nano particles at 100 and 200 ppm showed inhibition against *X. competrires* pv. *competrires* (8.00 and 13.00 mm) and *R. solanacearum* (11.33 and 12.33 mm) respectively. ZnNPs synthesized from *Pseudomonas fluorescens* and chitosan showed inhibition against *X. axonopodis* pv. *punicae* and *Ustilago nuda tritici*.

Green nano sulphur: Novel nano-molecule for sunflower powdery mildew management

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Green nanotechnology is one of the most lightening research areas in both multi-disciplinary and inter-disciplinary scientific community including agriculture and allied fields. Preparation of nanoparticles by using plant material helps to enhance the sustainability of synthesis process. Elemental sulphur is one of the oldest molecules used for better management of powdery mildew and rust diseases of many host plants. Present investigation was undertaken on synthesis of sulphur nanoparticles (SNPs) from pomegranate pericarp as a reducing agent and sodium thiosulphate as a precursor. Size and distribution of synthesized SNPs were confirmed by particle size analyzer (56.30 nm) and atomic force microscopy with average diameter ranging from 30-80 nm. Similarly, complete conversion of sodium thiosulphate to sulphur was confirmed by EDAX. Confirmed SNPs were evaluated against *Golovinomyces cichoracearum* the causal agent of sunflower powdery mildew under both *in vitro* and glasshouse condition. Synthesized SNPs were tested from 1 to 2000 ppm by spore germination inhibition method. Among tested concentrations, cent per cent inhibition was observed from 10 ppm onwards. Further, they were tested under glasshouse condition on DSFH-2 genotype along with wettable sulphur (0.3%) and hexaconazole (0.1%). The results showed that tested fungicides were on par with each other and with SNPs at 500 ppm. The least per cent disease index (PDI) of sunflower powdery mildew was observed at 500 ppm (13 PDI) compared to untreated control (85 PDI). No phytotoxicity symptoms were observed on sunflower at tested concentrations. It is inferred that SNPs are one of the alternative in efficient management of sunflower powdery mildew at lower concentration.

Pomegranate wilt: Understanding genetic diversity of pathogen and management options

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Pomegranate production has been constantly threatened with a cryptic wilt pathogen *Ceratocystis fimbriata*. Roving survey was undertaken in different locations in different districts of Karnataka. Highest disease incidence was observed in Vijayapura and Bagalkot districts with 23.22 and 23.09 per cent respectively. Bellary recorded the least incidence of 2.45 per cent among all the district surveyed. ITS sequencing was performed for molecular identification of the isolates, BLAST analysis revealed the identity of the isolates based on the BLAST score and homology match. Confirmed 28 pure isolates of *Ceratocystis fimbriata* were analyzed with 23 decamer RAPD primers. Results of the RAPD analysis indicated the high level of homogeneity among the isolates of similar geographic origin with an average of 53.33% polymorphism. Different *T. harzianum* isolates were tested for their efficacy against *C. fimbriata* in a dual culture experiment. All the tested isolates were found effective. However, isolates viz., UHSTh5, UHSTh43 and UHSTh48 recorded complete inhibition, whereas, the other tested isolates recorded more than 90% inhibitions except UHSTh17 and UHSTh19.

Molecular characterization of *Trichoderma harzianum* and *Trichoderma viride* isolated from rhizosphere soils by RAPD markers

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Twenty five isolates of *Trichoderma harzianum* and *Trichoderma viride* were obtained from rhizosphere soil of turmeric and ginger collected from Belagavi and Bagalkot districts of Karnataka. Among them, eight potential isolates based on their antagonistic activity were studied using RAPD PCR. The genetic relatedness of these potential isolates were analysed with five random primers and results in 85-100 per cent polymorphism. Cluster analysis was used to generate a dendrogram, grouped the isolates into two major clusters, first major cluster consisted of six *T. viride* isolates (viz., Tv-1, Tv-2, Tv-14, Tv-23, Tv-17 and Tv-8) and second major cluster included two *T. harzianum* isolates (viz., Th-18 and Th-25). Analysis of dendrogram revealed that the similarity coefficient ranged from 0.15 to 0.95.

Characterization of *Alternaria* species inciting sunflower blight

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Sunflower is one of the important oilseed crop of India. Among several biotic factors *Alternaria* blight has been considered as a potentially destructive disease causing reduction in seed yield by 27-80 per cent and oil yield by 17-33 per cent. Extensive research work has been done on this disease, yet there are many obscured aspects of the disease, which need immediate attention, very little work has been done on characterization of the species hence the present investigation were directed towards the characterizing the species inciting sunflower blight. Isolation of the fungus was made from typical leaf spot on infected plants collected from the field in *kharif*, *rabi* and summer. The isolates were initially identified based on spore character and colony morphology grown on PDA with that of previously described strains. Genomic DNA of the fungus was isolated by CTAB method. The PCR amplification of the fungal DNA was done using universal primers ITS1 and ITS4 and DNA sequences obtained from ITS rDNA were compared using bioinformatics tools like NCBI. In all the three seasons, mixed infection of *A. helianthi* and *A. alternata* was observed. Isolations made from small round leaf spot symptoms during initial stages of crop growth resulted in *A. alternata*. Whereas, isolation made from larger irregular leaf spot symptoms from matured plants resulted in *A. helianthi* on PDA. *A. alternata* was limited to lower leaves, whereas, *A. helianthi* was found associated with leaf and stem blight during later stages of crop growth. *A. helianthi* was the major species causing leaf blight in sunflower. Genomic DNA of the fungus isolated by CTAB method was observed by electrophoresis in 1.2 per cent agarose gel. The DNA obtained was about 7000-8000 bp approximately with a concentration of 91 $\mu\text{g}/\mu\text{g}$. The DNA sequences obtained were compared using bioinformatics tools like NCBI (National Centre for Bioinformatics) BLAST programme. Based on rDNA sequence comparisons, the identification of the isolates were confirmed as *A. helianthi* and *A. alternata*. Sequences were deposited in NCBI with GenBank accession numbers SUB2900726 MF563494. SUB2900741, MF563528, SUB2900747, MF563552, SUB2900750 and MF563553.

Development of multiple disease resistant rice through marker assisted selection

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Blast disease caused by *Magnaporthe oryzae* and sheath blight due to *Rhizoctonia solani* are the two major constraints for rice production. To manage these two diseases an effort was initiated at UAS Dharwad through Marker Assisted Backcross Breeding Approach. The major sheath blight resistance QTL qSBR11-1 was transferred from Tetep into BPT5204 Near Isogenic Line (NIL) which is already introgressed with blast resistance *Pi2* gene. Backcross population (BC₁F₂) genotyping was carried out to identify plants introgressed with sheath blight QTL, qSBR11-1 and blast resistance genes in different combination. Plants pyramided with *Pi1 + Pi2 + Pi54* and qSBR11-1 are identified and similarly plants having two *Pi* genes and QTL and one *Pi* gene and QTL are also identified.

Molecular validation of maize germplasm by using SSR markers

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Turicum leaf blight (TLB) and common rust (CR) diseases can greatly reduce grain yield of maize. Control of these diseases through conventional measures has been quite ineffective and difficult to sustain. The most feasible way to control them is by breeding and deploying resistant maize germplasm. This study was carried out to evaluate germplasm for their resistance associated to TLB and CR diseases by use of SSR markers and artificial inoculation with the two pathogens. Out of twenty (seventeen for TLB and three for CR) SSR markers used, four SSR markers were found polymorphic between the germplasm for TLB and one for CR. Four markers BnlG1662, Phi330507, Umc1728 and Umc2210 putatively linked to TLB resistance and Phi054 linked to CR resistance. Single marker analysis of germplasm confirmed that BnlG1662, Phi330507, Umc1728 and Umc2210 markers were closely linked to TLB resistant gene and accounted for 89.02, 90.71, 89.39 and 89.89 per cent of the total variance respectively and Phi054 found closely linked to CR resistant gene and accounted for 84.08 per cent of PVE(Phenotypic Variance explained by Environment).

Biogenic mediated synthesis of zinc oxide nanoparticles (ZnONPs) using *Pseudomonas fluorescens* and their efficacy against phytopathogens

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The integration of nanotechnology with plant protection sector in agricultural sciences has made tremendous advancement in plant health management. To rescue from pesticide resistance, metallic nanoparticles are future weapons in plant disease management. By considering the future challenges in agricultural sector, an effort was made to biogenic synthesis of Zinc oxide nanoparticles (ZnONPs) using *Pseudomonas fluorescens*. ZnONPs were synthesized by induction of heat to mixture of ZnO and *P. fluorescens* culture filtrate for ten minutes. The synthesized nanoparticles were characterized by using UV- vis spectrophotometer, Atomic Force Microscope (AFM), Particle Size Analyzer (PSA), Scanning Electron Microscope (SEM) and Energy Dispersive X-ray analysis (EDX). The size of the nanoparticles was found to be 67 nm and their size distribution was unimodal (100% in NICOMP distribution), that confirmed the synthesis of ZnONPs. The successfully synthesized nanoparticles were evaluated against phytopathogens viz., *Xanthomonas campestris* pv. *sesame* (Xcs) (Bacterial blight of sesame) and *Exserohilum turcicum* (Northern leaf blight of corn) with different concentrations. The results revealed that, ZnONPs effectively inhibited the spore germination of *E. turcicum* at 1000 ppm concentration and inhibited the growth of phytopathogenic bacteria, Xcs at 500 ppm concentration. The phytotoxicity studies on chilli seedlings revealed that, there was no toxicity symptoms noticed in the tested concentration of ZnONPs (up to 1000 ppm).

Green synthesis of chitosan-silver nanoparticles using pomegranate peel extract and their efficacy against phytopathogenic bacteria

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Nanotechnology is expected to open new avenue to fight against plant disease and resistance development of microorganisms to antibiotics using nano-scaled materials. So a great interest towards investigating bactericidal properties of nanoparticles as an alternative to antibiotics has been initiated. Chitosan-AgNPs were prepared by the reaction made between 1 per cent chitosan solution in acetic acid, 10 mM AgNO₃ and 1 per cent pomegranate peel extract under magnetic stirrer for 5 minutes at room temperature. The nanoparticles were characterized by Atomic Force Microscope (AFM), Particle Size Analyzer (PSA) and Scanning Electron Microscope (SEM) and their antibacterial activity against phytopathogenic bacterium, *Xanthomonas campestris* pv. *sesame* (Xcs) (bacterial blight of sesame) was tested. The average size of the nanoparticles was found to be in the range of 150-200 nm. The synthesized nanoparticles were evaluated against Xcs with different concentrations. The results revealed that, chitosan-AgNPs effectively inhibited the growth of Xcs at 50 ppm concentration.

RNA interference: A novel tool for viral disease management in vegetable crops

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Virus diseases are among the key limiting factors that cause significant yield loss and continuously threaten vegetable crop production worldwide. Resistant cultivars coupled with pesticide application are commonly used to circumvent these threats. One of the limitations of the reliance on resistant cultivars is the inevitable breakdown of resistance due to the multitude of variable virus populations, through either mutation or genetic exchange by recombination or re-assortment of genomic segments. Thus, exploiting biotechnological strategies that provide durable and broad-spectrum resistance over diverse environments are of paramount importance. In this regard, RNA interference (RNAi) technology has emerged to be a promising therapeutic weapon to combat the plant viruses. RNAi is a mechanism for RNA-guided regulation of gene expression in which immediately after plant virus infection, the replicative dsRNA intermediates or viral RNAs-induced dsRNAs, synthesized by RNA-dependent RNA polymerase 6 (RDR6) and suppressor of gene silencing 3 (SGS3), trigger post-transcriptional gene silencing (PTGS) in host cells. RNA interference (RNAi) carried out by delivering dsRNA or siRNA into different cells and tissue by agroinfiltration or micro-bombardment or virus induced gene silencing (VIGS). Some of the striking examples of viral disease management in vegetable crops through RNAi are resistance to *Pea early browning virus* in pea, *Potato virus X* in potato, *Tobacco rattle virus*, *Tomato yellow leaf curl China virus* and *tomato spotted wilt virus* in tomato and *bean golden mosaic virus* in common bean. Keeping in view the potentialities of RNAi technology, this technology can be exploited to combat emerging plant viruses in the near future for sustainable vegetable production.

Watermelon Bud Necrosis Virus (WBNV): An emerging disease of watermelon

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Watermelon Bud Necrosis Virus (WBNV) is one of the major limiting factors in production of cucurbits in India, causing losses up to 100% in watermelon, muskmelon, cucumber and ridge gourd. WBNV belongs to group tospoviruses (family *Bunyaviridae*, genus *Tospovirus*), which is enveloped isometric ssRNA virus with a tripartite genome containing small (S), medium (M), and large (L) segments of size 3.4, 4.7, and 8.9 kb, respectively. The typical symptom of WBNV includes mottling and yellowing of leaves, stunting of vines and dieback of buds and shoots. Watermelon bud necrosis disease is mostly monocyclic and transmitted by viruliferous thrips viz., *Thrips palmi* and *T. flavus* in a circulative and propagative manner after minimum inoculation access period (IAP) of 30 min. In order to diagnose the WBNV, serological (serogroup IV) and reverse transcription-polymerase chain reaction (RT-PCR) using virus-specific N-gene primers has been standardized and validated. There are only few genotypes conferring resistance to WBNV viz., *Citrullus lanatus* var. *citroides*, EC-393243, RHRWH-2 and Durgapur selection are reported. Till date there is no report of resistance cultivars available for WBNV. Hence, an integrated disease management (IDM) which includes phytosanitary, cultural practices, and bio-control agents and chemical measures based on epidemiological principles is an effective measure for WBNV management.

Detection of antibiotic genes from endophytic *Pseudomonas fluorescens* of cotton

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Fusarium wilt caused by *Fusarium oxysporum* f. sp. *vasinfectum* was formally identified early in the history of plant pathology and subsequently formed basis for recognition of other wilts. A patchy distribution of plants in the field results from seedlings that wilt and dry rapidly. Symptomatic older plants may be stunted and wilted. In Tamil Nadu, the wilt incidence was reported up to 25 per cent and yield loss of 10-50 per cent. Endophytes are sheltered from environmental stresses and microbial competition by the host plant and they seem to be ubiquitous in plant tissues, having been isolated from flowers, fruits, leaves, stems, roots and seeds of various plant species. For the permanent control of disease, the potential endophytes producing antibiotics was identified. The isolate CCLEPf from Coimbatore produced higher amount of antibiotics was confirmed by TLC and PCR by using gene specific markers. PCR amplification has confirmed that all the endophytic bacterial strains, belonged to *Pseudomonas* which were tentatively identified as the *Pseudomonas fluorescens* with the phenotypic and biochemical characterization. The production of antibiotics was detected through thin layer chromatography (TLC) with an R_f value for the isolate of endophytic *Pseudomonas fluorescens* producing DAPG (0.5), Phenazine (0.88), Pyrrolnitrin (0.60), Pyoluteorin (0.94) and Pyocyanin (0.10). The genomic DNA of endophytic *Pseudomonas fluorescens* was amplified with predicted fragment of DAPG (420bp), Phenazine (220 bp), Pyrrolnitrin (530 bp) and Pyoluteorin (359 bp). Thirty endophytes with the most promising levels of colonization in a range of host plants based on 16S rRNA gene sequence was identified.

Metabolic reprogramming in leaf of wild tomato provides resistance against *Alternaria solani*

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Alternaria solani causes early blight (EB) disease in tomato affecting its yield in tropical environment. Wild relatives such as *Solanum arcanum* might have a potential source of EB resistance. However, molecular mechanism for EB resistance largely remains unexplored. We explored non-targeted metabolomics on resistant and susceptible *S. arcanum* accessions upon *A. solani* infection to unravel metabolic modulation. More than 2000 putative potential metabolites were detected of which over 600 depicted significant changes in resistant and susceptible accessions. Majority of these EB-triggered metabolic changes were in steroidal glycol-alkaloids, lignins and flavonoids. This was in accordance with biochemical and gene expression studies of key enzymes from these pathways indicating their potential role in EB resistance. Interestingly, *S. arcanum* rWRKY1, a known transcription factor, physically interacted with MYB20 promoter in sequence-specific manner leading to activation of required defense metabolites. Overall, this study highlights key roles of steroidal glycol-alkaloids as phytoalexins and phenylpropanoids along with lignin accumulation as potential mechanistic basis of EB resistance in wild tomato.

Molecular characterization of *Cucumber mosaic virus* infecting banana (*Musa* spp. L.)

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Banana (*Musa* spp.) is the premier fruit of the Asia and Pacific region. It is affected by four known, relatively well-characterized viruses namely *Banana Bunchy Top Virus* (BBTV), *Banana Streak Virus* (BSV), *Cucumber Mosaic Virus* (CMV) and *Banana Bract Mosaic Virus* (BBrMV). Among these *Cucumber mosaic virus* belonging to genus *Cucumovirus* and family *Bromoviridae*, is a multicomponent single stranded virus, with three positive-sense RNA's. Molecular characterization studies were taken up to compare the homology of CMV infecting banana with the CMV infecting cucurbit by employing polymerase chain reaction (PCR) using CMV specific primers such as CMV-F and CMV-R, which resulted in expected amplicon of size ~657 bp for diseased sample. Cloning and nucleotide BLAST results revealed that the complete gene sequence of Uppina Betageri isolate of CMV coat protein gene had 99 per cent homology with CP gene of other known isolates of CMV infecting banana from Southern Karnataka. Phylogenetic analysis grouped CMV isolates into two main clusters and CMV infecting banana belongs to cluster II with 0.035 similarity co-efficient. The similarity coefficient ranged from 0.001 to 0.035 indicating poor level of divergence. UPGMA cluster analysis based on genetic distance coefficients clearly separated all the isolates. From the following studies it may be concluded that two Dharwad isolates were having 99 per cent homology and hence, two strains of CMV infected two different hosts rather than two distinct viruses.

Molecular characterization of begomovirus associated with bitter gourd yellow mosaic virus disease in Kerala

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Bitter melon, *Momordica charantia* (Cucurbitaceae), is a vegetable of nutritive and medicinal value that is cultivated throughout India and other tropical countries. Bitter gourd yellow mosaic virus disease (BGYMV) is transmitted by whitefly, *Bemisia tabaci*. The virus disease showing vein mottling, leaf curl and chlorosis was observed on bitter gourd in Trivandrum, Kerala, India during the surveys conducted in 2014. Infected bitter gourd leaf samples were collected and whitefly transmission was established in the laboratory. Minimum of two whiteflies were required to transmit the virus with 80% transmission. Whiteflies required 4 hours to acquire the virus and 6 hours to inoculate the virus for 60% transmission of the disease. The percentage of transmission increased with increase in both acquisition and inoculation feeding period. A pre-acquisition starvation period of 3 h ensured hundred per cent transmission of the disease. The begomovirus DNA- A and DNA-B components associated with virus was amplified by rolling circle amplification using Φ -29 DNA polymerase and sequences were characterized. The analysis of DNA-A sequences revealed that the virus isolate (BG1) showed 95% nucleotide identities with *tomato leaf curl New Delhi virus* (ToLCNDV) isolates infecting cucurbits. The complete genome of DNA-A was submitted to GenBank with Accession No. KP868764. The DNA B sequences associated shared 92% homology with ToLCNDV isolates. Based on the high sequence identities and close phylogenetic relationships, BGYMVD in Kerala was associated with ToLCNDV, a bitter gourd infecting begomovirus from Pakistan.

Genetic diversity of secondary endosymbionts of whitefly, *Bemisia tabaci* in Karnataka, India

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Whitefly, *Bemisia tabaci* is known to harbor prokaryotic symbionts and have been shown to have a variety of effect on their hosts such as net fitness benefit to infected individuals, increasing their survival and fecundity and temperature tolerance. *B. tabaci* harbors a primary endosymbiont *Portiera aleyrodidarum* and several secondary symbionts including *Hamiltonella*, *Arsenophonus*, *Cardinium*, *Rickettsia*, *Wolbachia* and *Fritschea*. The presence of secondary endosymbionts associated with *B. tabaci* from 5 different locations and on different hosts in Karnataka state, India and correlation between bacterial compositions of whitefly feeding on different hosts were studied. Analysis of the sequences of 16S rRNA and *wsp* genes showed the presence of previously reported secondary endosymbionts of *B. tabaci*. Based on the high sequence identities and close phylogenetic relationships, *Wolbachia* and *Hamiltonella* endosymbionts were detected in whiteflies from laboratory reared and all the populations collected from different locations and on different hosts viz., Doddaballapur (ridge gourd), Kolar (tomato), Hoskote (cucumber) and Chintamani (pumpkin) respectively.

Genetic variation among isolates of *Ceratocystis fimbriata* Ell. and Halst. causing wilt of pomegranate using RAPD markers

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Pomegranate wilt disease incited by *Ceratocystis fimbriata* Ell. and Halst. is one of the important diseases of pomegranate adversely affecting crop cultivation in all major growing regions of India. The fungus isolated was confirmed using morphology and molecular features. Nine isolates of the fungus selected from different geographical regions of Karnataka were analysed through four RAPD markers viz., A3, A9, A13 and B10. The primers showed amplification of different isolates with polymorphism between the isolates when compared to primers B10 and A13. Out of the 28 marker loci amplified, 13 were found to be specific for five species and only two loci were common in all nine samples indicating 83.2 per cent polymorphism. Genetic variation observed in the study was maximum where the primer A3 amplified a specific marker for Cf-B and Cf-K isolates separately. Similarly, the primer A13 amplified specific markers for the isolates from Cf-B. The primer B10 amplified specific markers for isolates from Cf-H and Cf-K and the primer A9 was specific to the isolate from Cf-K. Overall, maximum of 4 loci were specific to the isolate from Cf-H indicating the possibility of using these markers as DNA fingerprints for respective regions. Dendrogram obtained from RAPD analysis indicated three major clusters formed which separated Cf-R from rest of the isolates, The isolates from Cf-Ct, Cf-H, Cf-K, Cf-T and Cf-B were grouped in second cluster. While, third cluster consisting of isolates Cf-B, Cf-C and Cf-V. The average polymorphism percentage ranged from 33.33 to 83.20 per cent. RAPD profiles showed a high level of genetic variability among the isolates of *C. fimbriata*.

Molecular characterization and management of black leaf spot of papaya caused by *Asperisporium caricae*.

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Papaya is an important fruit crop both in tropical and subtropical regions. The crop is prone to infection by several diseases. Black leaf spot is emerging problem. The pathogen infected leaf bits showing typical symptoms were used for DNA isolation. The total DNA of *Asperisporium caricae* was isolated from the infected plant tissue and amplified using ITS region primers. The amplified region product was subjected sequencing. The BLAST analysis of the nucleotide sequence of ACK-1 had 97.00 per cent homology with *Asperisporium caricae* accession number NR119970, strain-CBS130298. For the management of the disease hexaconazole @ 0.1 per cent proved to be highly effective (PDI of 46.87 per cent), followed by mancozeb @ 0.25 per cent (PDI of 49.68 per cent) and difenconazole @ 0.1% and thiophonate methyl @ (0.1%) (PDI of 50.31 per cent each).

Partial purification and bioassay of pathogenic toxin produced by *Alternaria porri* on onion cultivars

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Onion is one of the oldest known important commercial vegetable crops growing in India. The purple blotch disease of onion is mainly caused by the fungus *Alternaria porri* is one of the yield limiting factor in major onion growing areas of north eastern Karnataka. The toxin from *A. porri* was partially purified and characterized by using Liquid Chromatography Mass Spectrometry (LCMS) method. The purified toxin from *A. porri* was reported as tentoxin with chemical name of Cyclo [N- methyl- L- alanyl-L-leucyl- (α Z) - α B- di dehydro- N methyl phenyl alanyl glycy] and with the molecular weight of 414 (Da) and chemical formula $C_{22}H_{30}O_4N_4$. It has retention time of 4.44 min detected in LCMS TOF ES+, against mass and number of charge ions. The bioassay of partially purified toxin on germination of onion seeds revealed that, the maximum inhibition of seed germination was in Bellary red (86.79%) and Arka Kalyan (65.13%) at 2000 ppm toxin concentration and least per cent inhibition of 16.19 and 7.86 per cent found at 50 ppm toxin concentration respectively and also the toxin has showed shoot and root length inhibition of 26.67 and 28.15 per cent and 52.98 and 48.19 per cent in Bellary red and Arka Kalyan at a toxin concentration of 2000 ppm respectively. Least inhibition of shoot and root length was observed at 50 ppm toxin concentration. Per cent inhibition of seed germination, shoot and root length inhibition in both the varieties is positively correlated with the toxin concentration. It indicates that, the toxin has the pathogenic nature to induce symptoms in the plant system and this is reported to be negative factor for plant health.

Impact of silver nanoparticles synthesized from *Solanum torvum* L. against bacterial plant pathogens (*Xanthomonas* spp. and *Ralstonia solanacearum*)

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Nanotechnology is gaining tremendous impetus in the agriculture sector. The development of eco-friendly metal nanoparticles is of great advantage compared to the chemically synthesized metal nano particles. The present study is aimed to investigate the biological synthesis, characterization, antimicrobial activity of silver nanoparticles (AgNPs) synthesized from *Solanum torvum* L. fruit pericarp against major bacterial plant pathogens. Fruit pericarp extract (5.0 %) obtained by boiling in distilled water was mixed with AgNO₃ (1mM) and incubated for 12 h at 80 °C. The reduced AgNPs were characterized by different methods, which include ultraviolet-visible spectroscopy, particle size analyzer, fourier-transform infrared spectroscopy (FT-IR), scanning electron microscopy (SEM) and X-ray energy dispersive spectrometer (EDS). The spherical shaped AgNPs were observed and it was found to be 62 nm (mean diameter). The characterized silver nano particles were studied for their efficacy against major plant pathogens, viz., *Xanthomonas campestris* pv. *campestris* and *Ralstonia solanacearum* by paper disk method. *In vitro* studies revealed that the silver nano particles at 100 ppm showed the inhibition zone of 8.0±0.8 mm and 11.33±0.75 mm for *X. campestris* pv. *campestris* and *R. solanacearum*, whereas positive control streptomycin at 500 ppm showed 15.67±0.8 mm against *X. campestris* pv. *campestris*. Phytotoxicity studies were carried out using 100 ppm of AgNPs on 20 days old cowpea plants, which showed no toxicity to the plant. The present finding is the first report of use of *S. torvum* pericarp in synthesis of AgNPs and is found to be effective against *X. campestris* pv. *campestris* and *R. solanacearum* at lower concentration.

An *in-vitro* study of the antifungal activity of nanoparticles against *Colletotrichum gloeosporioides* (Penz.) causing anthracnose of mango

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Anthracnose of mango caused by *Colletotrichum gloeosporioides* (Penz.) is one of the most important pre and post harvest disease of mango causing major economic loss both in tropical and subtropical countries. Nano particles have exhibited antimicrobial activity, and exploiting them would be another solution to suppressing the pathogen. *In vitro* antifungal activity of silicon carbide, copper oxide silver nitrate, iron oxide, carbon, magnesium hydroxide and zinc oxide nanoparticles at concentrations of 10, 50 and 100 ppm was studied on *Colletotrichum gloeosporioides* causing anthracnose of mango. Among the seven nanoparticles tested under *in vitro* conditions, for their antagonistic effect *in vitro*, most of the nanoparticles did not show mycelial inhibition at 10 ppm, 50 ppm and 100 ppm concentration. At 50 ppm concentration, only zinc oxide showed inhibition of 7.08%. At 100 ppm, maximum mycelial inhibition of 42.92 per cent was seen by zinc oxide nano particle. Silver nitrite (7.08%), iron oxide and silicon carbide were on par with each other in inhibiting the mycelia growth at 100 ppm.

Optimization of loop-mediated isothermal amplification assay for detection of *tomato leaf curl New Delhi virus* associated with ridge gourd yellow mosaic disease

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Ridge gourd yellow mosaic disease (RgYMD) caused by strain of tomato leaf curl New Delhi (ToLCNDV) is newly emerged disease in ridge gourd growing areas in southern India. Detection of this virus is essential to manage the disease, particularly in healthy seed production systems. Large scale testing of plants demands a simple, quick, rapid and sensitive assay. Hence, loop-mediated isothermal amplification (LAMP) method was developed for specific detection of ToLCNDV in ridge gourd. This assay helps to diminish the time required for diagnostic assays like ELISA, polymerase chain reaction (PCR) etc. The assay was based on a six set of primers targeting the coat protein gene region of viral genome and successfully detected ToLCNDV. LAMP assay was optimized using different concentrations of inner and outer primers, incubation time and different concentrations of template DNA. The reaction was carried out at 65°C for 45 min and reaction is terminated by keeping it in 80°C for 10 min. The results were assessed by 2.0 per cent agarose gel electrophoresis and also by visual observation of colour change directly in the tube with nucleic acid stain dyes which allowed easy detection. The assay successfully detected the virus in infected plants collected from ridge gourd fields whereas no cross-reactions were observed with healthy plants. The LAMP method would be more useful than the PCR method for detection of ToLCNDV infection in ridge gourd plants because LAMP assay was accomplished in the water bath either free from any thermal cycler machine or sophisticated laboratories facility. The results indicated that LAMP assay will be useful for monitoring and detection of ToLCNDV associated with RgYMD.

Microwave assisted synthesis of green silver nanoparticles (Ag NPs) using extract of pomegranate peel and their antifungal activity

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Silver nanoparticles are well known for their antifungal and antibacterial properties. In the present study simple, rapid and ecofriendly method of synthesis of AgNPs was investigated using pomegranate peel extract as a reducing agent and the reduction process was assisted by exposure to microwaves for 90 seconds at 800 watt. Change in the colour to dull brown indicated the formation of nanoparticles. Synthesized AgNPs were characterized by UV-visible spectrophotometer, Particle size analyzer (PSA), atomic force microscopy (AFM) and scanning electron microscope (SEM). Mean diameter of AgNPs was found to be 46 nm. Resulted AgNPs were kept for autoclave at 121 °C at 1.1 kg/cm² for 15 minutes and they were stable. Pomegranate peel extract acted as good reducing agent as well as capping agent leading to the formation of stable nano suspension. Synthesised AgNPs were evaluated to know antifungal activity against *Bipolaris sorokiniana* (spot blotch of wheat) by using spore germination technique with various concentrations (1, 2, 3, 4, 5 and 10 ppm). The result revealed that, AgNPs completely inhibited the spore germination at 2 ppm concentration. Phytotoxicity of these concentrations was also studied on tomato seedlings under glass house condition.

Molecular characterization of phytoplasma associated with french bean (*Phaseolus vulgaris*)

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French bean (*Phaseolus vulgaris*) is herbaceous plant commonly known as dwarf bean, kidney bean and common bean belongs to the family Fabaceae, grown as a human food crop and fodder worldwide. Now days french bean crop is infected by number of diseases among them occurrences of phytoplasma diseases are common. Plants showing yellowing and size reduction of leave and witches broom symptoms have been observed in farmer's field in Kolar, Chickballapur, Doddaballapur and Bengaluru rural areas. The incidence of such symptoms varied from 0.5 to 6.7%. For confirmation of phytoplasma infection, symptomatic and asymptomatic french bean samples were collected from field and total DNA was extracted by using a modified CTAB method. Detection of phytoplasma was done by using specific primers P1/P7 and secYF2/R2 for 16Sr DNA and secY genes. The products of expected size 1.7 kb and 1.5 kb were obtained by PCR, cloned sequenced and compare with the 16S rRNA and sec gene phytoplasma sequences available in the NCBI database. 16Sr RNA and secY gene sequences of french bean phytoplasma shared highest nucleotide identity with 'Candidatus Phytoplasma australasiae' (Ca.P. australasiae) 16Sr II group isolates from different parts of the world. Phylogenetic analysis also revealed the current study of phytoplasma closely clustered with the Ca. P. australasiae 16Sr II subgroup. The virtual RFLP pattern of French bean 16S rDF2nR2 fragment is different from the reference patterns of all previously established 16Sr II subgroups. The phytoplasma detected in the present study infects french bean and causes little leaf disease should be considered as a new subgroup of group 16Sr II.

Nano - In its leeway on plant pathogens and in other sectors

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Nanotechnology where diverse nanomaterial are being used in different sectors for implementation its functions. From agriculture to drug delivery system where this prime technology exhibits a prime importance in the present decade. The use of nanotechnology in agricultural where host is the most important part. In the present day the supervision of plant diseases may consider by DNA-directed silver nanoparticles on graphene oxide sheet (Ag@dsDNA@GO) which act as an antibacterial agent of plants host by destroying the bacterial cell wall. The pathogenic bacteria may control by the above mentioned nanomaterials. Several experiments clearly denotes that the systemic acquired resistance (SAR) is present in plants and maintains the resistance of the plants. The Acibenzolar-S-methyl (ASM) activity may be due to-systemic acquired resistance (SAR) inducer activity and helps in maintaining the plant defense function. The proposed functions may increase due to the transcription of stress-related genes of plants. Thus, the bacterial spot disease may control by the Ag, Cu, CuO, ZnO, TiO₂ nanoparticles as well as with carbon based graphene oxide (GO) nano materials. Moreover, AgNPs are the most effective biocides to control plant pathogens. The power of nanotechnology is rooted in its potential to transform into revolutionize in multiple technology and industry sectors, including aerospace, agriculture, biotechnology, homeland security and national defense, energy, environmental improvement, information technology, medicine, transportation and so on. Recognition in some of these areas are in progress to detect the point wherever it is now possible to categorize the applications of nanotechnology in the above mention essential things where we live in.

Technical Session VIII

Management of plant diseases through chemicals

Efficacy of combi-products against *Cylindrosporium* leaf spot pathogen of *Nothapodytes nimmoniana* (an anti-cancer drug yielding tree) under *in vitro* conditions

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Recently, several tree species of the Western Ghats are gaining international importance due to their newly identified pharmacological and curative properties and as well to the threat posing to them by abiotic and biotic factors. One such medicinal tree is *Nothapodytes nimmoniana*. It is the source of chemical camptothecin (CPT). Camptothecin is among the top three drugs in demand in the world right now for cancer treatment. Of late this crop is being found to suffer from fungal leaf spot disease caused by *Cylindrosporium mappiae* causing cent percent defoliation. This disease is reported to be due to the soil borne pathogen and the pathogen not only affects the leaves but also most economic parts twigs and barks also. Hence, considering the medicinal importance of this crop and disease severity *in vitro* management using combi products was tried during 2016-17. Different combi-products were tried at 0.1 and 0.2 per cent concentrations. Among the different combi-products cent per cent inhibition was recorded in hexaconazole 5% +captan 70% WP, hexaconazole 4% + zineb 68%, WP and trifloxistrobin 25% + tebuconazole 50%, WC at both 0.1 and 0.2 per cent concentrations. These treatments were found significantly superior to carbendazium 12% + mancozeb 63%, However, all the treatments were found superior *vis-a-vis* untreated control. Thus, exploring the combi products play a major role in management of leaf spot disease of *N. nimmoniana* under high disease pressure and also as component in integrated disease management.

Management of late blight of potato incited by *Phytophthora infestans*

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During *Kharif* and *Rabi* seasons in every year under adverse weather condition, the late blight of potato causes widespread crop failures throughout southern Karnataka including Hassan, Chikkamagalore, Chickaballapura, Kolar and Bengaluru rural districts. An experiment was implemented on management of late blight of potato incited by *Phytophthora infestans* at Horticulture Research and Extension Station, Hassan, Karnataka, consecutively for three years during *Kharif* season of 2014-15, 2015-16 and 2016-17. In the study there were six treatment combinations imposed on potato crop, among them crop sprayed with fenamidone + mancozeb (0.3%) noticed lowest late blight index of 22.92 per cent with highest mean marketable tubers yield of 14.39 t/ha and blighted tubers of 0.65 t/ha followed by crop sprayed with dimethomorph (0.1%) + mancozeb (0.3%), wherein 26.93 per cent of late blight index was noticed with mean marketable tuber yield of 12.34 t/ha and blighted tubers of 0.90 t/ha compared with check (57.66 %). Therefore from the study, it was concluded that foliar application of combi product of fenamidone + mancozeb (0.3%) was found effective in managing the late blight with production of higher marketable tuber yield.

Efficacy of new fungicides against stem rot of groundnut

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A field experiment was carried out during *kharif* 2008, 2009 and 2010 in Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, to know the efficacy of different fungicides against stem-rot of groundnut. All the seed treatment fungicides were found effective in reducing the stem rot incidence over untreated check. However, the fungicide tebuconazole 2 DS (@1.5 g/kg) has emerged as the most effective by recording least incidence of stem rot (8.44%) followed by carbendazim + mancozeb (@ 3.0 g/kg) (8.82% stem rot). As far as yields were concerned, the highest yields were recorded in carbendazim + mancozeb (2648.92 kg/ha) followed by carboxin (@ 2.0 g/kg) (2605.07 kg/ha). On basis of economics, seed treatment with carboxin (@2.0 g/kg) has been found to be economical by recording highest cost benefit ratio of 1:2.54

Vine dipping in Bordeaux mixture - control foot rot

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In India betelvine is known as 'Paan'. It is the most important commercial crop and also most profitable amongst all cultivated crops which plays a vital role in the overall livelihood security of farm families. Cultivation of betel vine is highly risky and returns are uncertain because of its proneness to several diseases, aggravated by the moist and humid conditions of the plantation, that in turn are prerequisites for good harvest. Obviously the major constraint to cultivation of betelvine is its diseases that cause severe damage to foot, stem, root and foliage. The extent of losses varies from 5-90 per cent. Low temperature, high humidity and diffused light that prevail inside the boroj favours vine growth and are also congenial for the growth of the pathogen. Dipping of vines in Bordeaux mixture before sowing improves the vine growth and impart resistance to vines up to 30 days. Bordeaux mixture treatment gives minimum incidence of foot rot disease, maximum growth and yield parameters like vine elongation fresh weight of leaves leaf yield and keeping quality improved than normal. This concept is very important to get disease free vines and maximum yield in betelvine. The best method to manage diseases is vine treatment with Bordeaux mixture.

Efficacy of new fungicides against leaf and neck blast diseases of paddy

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Rice (*Oryzasativa* L.) is one of the most important cereal crop of family Poaceae. Rice suffers from many diseases caused by fungi, bacteria, viruses, phytoplasma, nematodes and other non-parasitic disorders. Among the fungal diseases, blast is considered as a major threat to rice production because of its wide spread distribution and its destructiveness under favourable conditions. In view of these it was thought to contain this disease and fungicides would give a better solution to address the blast and to find out efficacy of fungicides is under field conditions, experiments were conducted during *Kharif* 2014 and 2015 at Agricultural and Horticultural Research Station, Ponnampet and among them ICF-110 (tricyclazole 45% + hexaconazole 10% WG) @ 0.1%, Merger (tricyclazole 18%+ mancozeb 62% WP) @ 0.25%, tricyclazole 75% WP0.06%, hexaconazole 5% EC @ 0.2%, mancozeb 75%WP @ @ 0.2%, Companion (mancozeb 63% WP + carbendazim 12% WP) @ 0.15% and carbendazium 50%WP@ 0.1% were found effective in controlling the blast disease. Among the treatments pooled data of *kharif*2014 and 2015results revealed that ICF-110 (tricyclazole 45% + hexaconazole 10% WG) @ 0.1% shows that the least per cent disease index of leaf blast (21.15 PDI) and neck blast (17.43 PDI) respectively, followed by Tricyclazole 75% WP0.06% shows that the per cent disease index of leaf blast (23.25 PDI) and neck blast (19.65 PDI) respectively, both the treatments were on par and superior to all other treatments and significantly reduced leaf and neck blast disease, but in case of check treatment plot in which maximum per cent disease index of leaf blast (67.07 PDI) and neck blast (61.93 PDI) respectively. Significantly higher the grain yield were observed in ICF-110 (tricyclazole 45% + hexaconazole 10% WG) @ 0.1% treated plot of about 4450.00 kg/ha, followed by tricyclazole 75% WP0.06%treated plot of about 4246.30 kg/ha compared to check (2641.20kg/ha).

Management of downy mildew disease in cucumber

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Downy mildew disease (DMD) of cucumber is destructive in nature and reduces fruit yield. Fungicides were used to control DMD but still DMD occurs. Hence, for the good alternative fungicide to control DMD, field experiment on efficacy of ametoctradin + dimethomorph against DMD was conducted in *rabi* and *kharif* season. Observations on per cent disease index (PDI), fruit yield and phytotoxicity of fungicides on cucumber were recorded. In *rabi* season, ametoctradin 300g/l +dimethomorph 225 g/l SC with 525g. a.i., reduced PDI maximally (14.74 %) followed by Zampro 525 SC (15.12%). In *kharif* season, Ametoctradin 300g/l +Dimethomorph 225 g/l SC with 525g.a.i reduced PDI maximally (13.63%) followed by Zampro 525 SC (14.09%). In *rabi* and *kharif* season, ametoctradin 300g/l + dimethomorph 225 g/l SC with 525g.a.i treated plants produced significantly higher yield of cucumber fruits (23.33t/ha, 24.23t/ha) followed by zampro 525 SC (22.92t/ha, 23.00t/ha) over other fungicides. ametoctradin 300 g/l + dimethomorph 225 g/l SC @ 1000 ml/ha and @ 2000 ml/ha were not toxic to cucumber plant in *rabi* and *Kharif* season. The results concluded that use of ametoctradin 300g/l + dimethomorph 225 g/l SC with 525g. a.i., resulted in reduced PDI and improved yield.

Use of new chemical fungicides in the management of plant diseases

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Recently it has become increasingly difficult for growers to control crop diseases. Genetic resistance of crops towards diseases has been in many cases short-lived (for example cereal rusts) and GMOs have only limited success for disease control and acceptability. With more intensive cropping, new diseases have arisen which are devastating if not controlled. In addition, new races and more aggressive pathotypes of diseases have arisen. All these changes require the rapid development of chemical control measures to prevent economic disaster, since reliance on genetic resistance and cultural techniques have been insufficient. Intensive use of chemical control measures has in turn led to its own challenges, including resistance to fungicides. Field experiment was conducted at MARS, UAS, Dharwad during the *rabi* season 2005-06. Results indicated that propiconazole, triadimefon and hexaconazole (0.1 %) were found significantly superior to others with respect to low wheat rust and high grain yield. During 1999-00 and 2000-01 trial was conducted to know the effectiveness of the new fungicides on spot blotch of wheat. Hexaconazole (0.1 %) was found to be significantly superior followed by propiconazole (0.1 %). Therefore, two spray of propiconazole (0.1%) can be strongly recommended for management of leaf rust as well spot blotch of wheat. Two separate field trials on fungicidal evaluation were conducted at ARS, Arabhavi, UAS, Dharwad during *Kharif* 2013-2014 under irrigated conditions. Azoxystrobin 18.2 + cyperconazole 7.3 (Amistar Xtra 280 SC) @ 0.125% treated plot was significantly superior over other treatments in reducing the *Turcicum* leaf blight maize disease (16.6 and 13.33 PDI) and recorded highest grain yield (62.9 and 34.74q/ha). Amistar Xtra 280 SC (azoxystrobin 18.2 + cyperconazole 7.3) @ 0.1% & 0.125 % and azoxystrobin 23 SC @ 0.1% were also effective in significantly reducing common rust incidence. Two years (2015 and 2016) new fungicide molecule has been tested against rust as well *Alternaria* leaf spot of soybean at ARS, Nippani. By considering the two years data it was clearly indicated that the foliar spray of tebuconazole 430 SC @ 258 a. i. (g)/ha showed good control of rust (14.43 PDI) as well *Alternaria* leaf spot (19.67 PDI) disease with considerably higher yield (23.78 q/ha). Powdery mildew of okra caused by *Erysiphe cichoracearum* DC ex Merat was optimum in untreated check and maximum control of the disease was observed in the treatment viz., Nativo (tebuconazole 50% + trifloxystrobin 25% WG) @ 150+75 a. i. (g)/ha. Highest okra pod yield of 14.07 t/ha was harvested in the same treatment. Three different fungicides were tested against damping off disease in tobacco at ARS, Nippani during *kharif* 2016. All three fungicides were found significantly superior to control in reducing the damping off disease in tobacco nursery. However, azoxystrobin 23 SC @ 0.1 % was recorded least percent damping off (3.4 %). Control plot recorded 44 % damping off. Highest numbers of transplantable seedlings (632) were obtained from metalaxyl 4% + mancozeb 64% (Ridomil Gold 68 WP) @ 0.2 % drenched plot. *Rhizactoni solani* was associated with damping off disease. The pathogen which survived in the nursery beds were tested its resistance development with three concentrations. Significant mycelia inhibition (84.91 %) was observed in case of fenamidone 10 % + mancozeb 50WP (Sectin 60WP) @ 0.3 % followed by metalaxyl 4% + mancozeb 64% (Ridomil Gold 68 WP) @ 0.2 % (81.07%) The sustainable use of fungicides to prolong their effectiveness and usefulness to growers is key, and the implementation of resistance management strategies an essential part of this. Only if the long-term effectiveness of fungicides can be ensured will industry invest the money and resources required for their discovery and development, especially considering the high standards of today's registration requirements. The Fungicide Resistance Action Committee (FRAC) and its network play a vital role in the design and support of these strategies.

In vitro evaluation of contact and combi product fungicides

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Three contact and two combi product fungicides were tested against *U. cicerisarietini*. The inhibition of uredospore germination was 100 per cent at 0.25 and 0.30 per cent concentration followed by 0.20 and 0.15 per cent concentration. At 0.15 per cent concentration, hexaconazole + zineb (97.51%), carbendazim + mancozeb (97.14%), sulphur (94.36%), chlorothalonil (91.68%) and mancozeb (90.73%) inhibition of uredospore germination was observed. At 0.20 per cent concentration, hexaconazole + zineb (100%), carbendazim + mancozeb (100%), sulphur (98.96%), mancozeb (98.92%) and chlorothalonil (97.10%) inhibited spore germination.

Study on bio efficacy of Proquinazid 20 EC against powdery mildew of chilli

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Chilli (*Capsicum annum* L) is a tropical and subtropical crop grown all over India. It is an important versatile spice as well as vegetable crop. Chilli suffers from many diseases caused by fungi, bacteria, viruses, nematodes and also abiotic stresses. Among the fungal diseases powdery mildew caused by *Leveillula taurica* (Lev) Arn. is serious and also major limiting factor in cultivation of chilli. Experiment was conducted at MARS, Raichur, to study the bio efficacy of new molecules Proquinazid 20 EC against powdery mildew of chilli during 2014-15 and 2015-16. During 2014-15 result revealed that at 15 days after 3rd application, minimum powdery mildew PDI (31.85 %) was observed in Proquinazid 20 EC at 50 g a.i., / was on par with Proquinazid 20 EC at 40 g a.i., / ha (32.59 %). Significantly highest yield of dry chilli was recorded in of Proquinazid 20% EC @ 40 g a.i., /ha (22.88 Q/ha) was on par with Proquinazid 20% EC @ 50 g a.i., /ha(21.92 Q/ha) and lowest dry chilli yield of (9.16 Q/ha) was observed in the untreated control.

During 2015-16 At 10 days after 1st, 2nd and 3rd application, significantly lowest powdery mildew PDI (%) was observed in Proquinazid 20EC @ 50 g a.i.,/ha (8.14, 14.81 and 18.96 respectively) and was on par with Proquinazid 20EC @ 40 g a.i.,/ha (11.11, 18.15, 20.37 and 22.22 respectively). These two treatments were significantly superior over the standard treatments, Triademefon 25WP, Sulphur 80% WP and Hexaconazole 2% SC. The untreated control recorded significantly highest PDI (%) at all the observation dates. Significantly maximum yield of dry chilli was recorded in of Proquinazid 20% EC at @ 50 g/ha (33.67 Q/ha) and was on par with Proquinazid 20% EC at @ 40 g/ha (30.69) and least yield (18.87 q/ha) was recorded in the untreated control.

Based on two year studies, it can be concluded that the new fungicide, Proquinazid 20% EC @ 40 g a.i.,/ha was effective in reducing the severity of powdery mildew disease and there by recording higher dry chilli yield.

Trifloxystrobin+Tebuconazole 75WG : A newer option in the management of rust and pod blight diseases of soybean in India

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Field screening of new fungicide molecules against soybean rust and anthracnose was taken up during *Kharif* growing season 2014 and 2015 at the Main Agricultural Research Station, Dharwad. Seven treatments were tested under natural epiphytotic conditions of both rust and pod blight severity. The pooled analysis over two years revealed that among the treatments imposed, spraying with trifloxystrobin + tebuconazole 75WG @0.7g/L recorded minimum per cent disease index of 25.5 and 15.1 rust and pod blight respectively followed by 32.6 and 18.1 PDI in case of trifloxystrobin + tebuconazole 75WG @0.6g/L against rust and pod blight respectively. The positive check hexaconazole @ 1ml/L recorded disease severity of 29.1 and 26.8 respectively. The maximum severity was recorded in untreated control (78.50 PDI Rust and 40.9 PDI Pod blight). The reduction in PDI, increase in seed yield and B : C ratio was observed in above said treatments. Thus, two sprays with trifloxystrobin + tebuconazole 75WG @0.7g/L be recommended in management of rust and pod blight diseases in northern Karnataka.

Effect of different fungicides on leaf spot disease of sapota caused by *Phaeophleospora indica* Chinn

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An experiment was conducted to find out the effective fungicides for the control of leaf spot disease of sapota at Agricultural Research Station, Kawadimatti, University of Agricultural Sciences, Raichur, during the year 2014 and 2015. The experimental results revealed that carbendazim 12% + mancozeb 63% WP (0.25%) effectively controlled the leaf spot disease followed by chlorothalonil 75 WP% (0.25%), zineb 68% + hexaconazole 4% WP(1.20%) followed by carbendazim. 50% WP (0.1%) and mancozeb 75% WP (0.2%). With regard to yield, the highest yield as recorded in the treatment of carbendazim 12% + mancozeb 63% WP followed by chlorothalonil 75 WP% (0.25%) followed by carbendazim. 50% WP 0.1%. The benefit cost ratio was more in the treatment of carbendazim 12% + mancozeb 63% WP (0.25%).

Evaluation of bio-efficacy of Merivon 500 SC (fluxapyroxad 250 g/l + pyraclostrobin 250 g/l) against powdery mildew disease of cucumber

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Cucumber (*Cucumis sativus*) is an important tropical vegetable crop. The cucumber is cultivated both as a summer and rainy season crop. The crop is prone to be affected by several diseases like Powdery mildew, Alternaria blight, Angular leaf spot, Anthracnose etc. Among them, powdery mildew is known to occur regularly and causes heavy losses. For the evaluation of bio-efficacy of Merivon 500 SC against Powdery mildew of cucumber, a field experiment was conducted using different fungicides consisting of 9 treatments with three replications in a RCBD during the *Kharif* and *Rabi* 2016-17 at College of Horticulture, Bengaluru and two sprays were given at 10 days interval after the onset of the disease. Among the different treatments, during *Kharif* and *Rabi*-2016, the disease severity was ranged from 2.96 to 5.93 per cent and 3.70 to 8.15 per cent respectively. The treatment T₄ Merivon 500 SC @ 300 ml/ 500 ltr was found to be very effective in reducing the disease severity (2.96 and 4.44 per cent powdery mildew on leaves) with the yield of 15.17 t/ha followed by T₃ Merivon 500 SC@250 ml/500 ltr (3.70 and 5.18 per cent powdery mildew on leaves) with the yield of 15.33 t/ha. The results of the treatments T₃ and T₄ were statistically on par with each other and superior over the control (45.93 per cent on leaves) and all other treatments of the experiment. No phytotoxicity could be seen in any of the doses tested.

Field evaluation of antibiotics/ bactericides/ nano-particles for the management of bacterial blight of pomegranate caused by *Xanthomonas axonopodis* pv. *punicae*

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Pomegranate bacterial blight caused by *Xanthomonas axonopodis* pv. *punicae* is the major constraint for production of quality fruit. A field experiment was conducted to know the *in vivo* efficacy of the available antibiotics, bactericides and silver nano particles. The data revealed that before spray PDI on leaves and twigs were in the range of 49.7 to 54.00 on leaves and 29.0 to 34.00 on twigs. At the end of fifth spray Least PDI was observed in Treatment 5 comprising the spray combination of 2- bromo-2-nitro propane-1,3diol (Bactrinashak) + streptomycin sulphate + tetracycline hydrochloride + COC+ H₂O₂ and treatment followed by Treatment 4 (2- bromo-2-nitro propane-1, 3diol (Bactrinashak) + streptomycin sulphate + tetracycline hydrochloride + COC) with values of 19.70 and 20.70 per cent on leaves and 12.30 and 13.70 on twigs, respectively. The maximum PDI of 61.70 on leaves and 41.30 on twigs was observed in control plants (T₆). The per cent disease reduction over control was maximum 68.07 and 70.21 per cent on leaves and twigs, respectively in T₅ followed by T₄ (66.45 and 66.82% on leaves and twigs, respectively). The per cent disease incidence before spray on fruit was in the range of 27.0 to 31.0 per cent in the orchard. At the end of 5th spray, Least PDI was recorded in T₅ (11.70%) followed by T₄ (13.00 %). However, maximum PDI on fruit was observed in untreated control plants to a tune of 39.70 per cent. Per cent disease reduction over control was maximum in T₅ (70.52%) followed by T₄ (67.25%). Treatment T₅ was supported comparatively better yield (6.49 t/ha) followed by T₄ (5.68 t/ha).

Management of turcicum leaf blight and common rust of maize

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Turcicum leaf blight (TLB) and common rust (CR) are major foliar diseases on maize in all growing regions of Karnataka. Thirteen fungicides were evaluated *in vitro* and field condition against TLB and CR caused by *Exserohilum turcicum* and *Puccinia sorghi* respectively. Among them strobilurin group fungicides in combination with triazole fungicides are found effective in the management of diseases. The field experiment was conducted at Main Agricultural Research Station, Dharwad and Agricultural Research Station, Nippani during *kharif* 2016. *In vitro* results revealed that tebuconazole 50 % + trifloxystrobin 25 % WG found to be effective against both *E. turcicum* and *P. sorghi* followed by azoxystrobin 20% + tebuconazole 20% SC. Under field condition combination of tebuconazole 50 % + trifloxystrobin 25 % WG followed by azoxystrobin 20 % + tebuconazole 20 % SC @ 2.5 g/lit were found effective in the management of TLB (8.67 and 10.33 % respectively) and CR (4.00 and 6.67 % respectively). Allied to yield, more significant increase in grain (111.60 q/ha), fodder yield (11.51 t/ha) and hundred grain weight (34.22 g) was recorded in treatment tebuconazole 50 % + trifloxystrobin 25 % WG and while, in azoxystrobin 20 % + tebuconazole 20 % SC recorded grain yield (104.02 q/ha), fodder yield of 11.30 t/ha and hundred grain weight (32.43 g) this was significantly superior with respect to disease control and yield aspects. The results with regard to economic analysis revealed that the maximum benefit-cost (B:C) ratio of 3.01 was recorded where in maize crop sprayed with propiconazole 25 % EC.

Chemical control of *Alternaria* leaf blight of chrysanthemum caused by *Alternaria chrysanthemi*

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Chrysanthemum (*Chrysanthemum morifolium*) grown especially for its flower is a potential money-spinner, as its cultivation involves less labour cost while the returns is higher. Besides, it is also grown for extraction of pyrethroids odour in perfumery. The area under chrysanthemum in Haveri district is 456 ha. with production of 6501 tonnes of flowers is increasing with every passing year with intensive improved production technologies, crop homogeneity, monocropping and severity of disease incidence was also in increasing trend. Chrysanthemum like all other crops is afflicted many diseases. Important among them being *Alternaria* leaf blight caused by *Alternaria chrysanthemi* as it greatly reduces the market value of the flowers. This disease causes losses to an extent of 70% is widely prevalent in the chrysanthemum fields of Haveri district. The problem is perennial, as the fungus remains viable in the debris for more than a year. The recommended chemical control measure is spray of Mancozeb @0.2 per cent at the onset of the disease. However, the chemical has been ineffective in controlling the disease in this region as has been experimented in the farmer's field. Hence, an experiment was conducted to know the efficacy of propiconazole (0.1%) over the recommended mancozeb (0.2%) for the management of *Alternaria* leaf blight in chrysanthemum. The results revealed that decrease in per cent disease incidence from 36.20% to 8.64% while the yield increased to an extent of 27.38% over the plots in which mancozeb was used. This indicated the efficacy of propiconazole over mancozeb spray. Two sprays of propiconazole (0.1%) required soon after disease incidence to an interval of 12-15 days.

Development of effective and safe chemical module against postharvest diseases of coconut

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Coconut is an important plantation crop in India. 30 – 35 per cent of coconut produce is used for milling copra and oil extraction in the country. From harvest to final copra preparation or oil extraction, there are many reasons to deteriorate the quality of copra at farmer's level. Losses due to post harvest and storage rots in coconut ranges between 3.5 to 12 per cent. Present study aimed at isolation of causal organisms of copra rots, identification of effective chemical module against the pathogens and to study the bio safety measures. Isolation studies revealed that *Aspergillus flavus*, *A. niger*, *Rhizopus spp.*, *Dreschlera spp.*, *Botryodiplodia spp.*, *Penicillium spp.* and *Bacillus spp.* are the commonly associated copra pathogens during storage. Different chemical and natural preservatives were tested for their efficacy against major copra pathogens. Among the chemical preservatives, combination of menadione (400ppm) and benzoic acid (750ppm) was found effective in preventing *Aspergillus flavus*, *A. niger*, *Rhizopus spp.* and *Penicillium spp.* under *in vitro* and *in vivo* conditions. The natural preservative, methyl eugenol was found effective at 0.3% and above concentrations in preventing *Aspergillus flavus*, *A. niger*, *Rhizopus spp.* and *Penicillium spp.* under *in vitro* and *in vivo* conditions. Further, the biosafety studies of these preservatives on copra were taken up in wistar rats. Natural preservative, methyl eugenol at 1.0% concentration and combination of chemical preservatives, menadione (750ppm) and benzoic acid (1100ppm) were given orally to wistar rats and parameters such as mortality, body weight, haematological and histo pathological were studied. The toxicological results confirmed that natural preservative, methyl eugenol (1% concentration) and chemical preservative combination, menadione (750ppm) and benzoic acid (1100ppm) were non toxic to wistar rats under the tested experimental conditions and are safe to use against postharvest mycoflora of coconut.

Management of powdery mildew and leaf spot diseases of sesamum

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Sesame (*Sesamum indicum* L.) is an important oil seed crop of India. Powdery mildew and *Cercospora* leaf spot are major problem in the cultivation of this crop. Field experiment was conducted during Kharif 2016, to evaluate the efficacy of nine different fungicides to manage powdery mildew and leaf spot diseases of sesamum. The results revealed that, the per cent disease index (PDI) of powdery mildew was significantly less (7.89) in propiconazole 25% EC sprayed plot followed by wettable sulphur (8.96), carbendazim 12% + mancozeb 63% (13.85) and tebuconazole 50% + trifloxystrobin 25% WG (15.67) compared to unsprayed plot (91.55) respectively. Similarly, the disease severity of *Cercospora* leaf spot was significantly less (9.07%) in Propiconazole 25% EC sprayed plot followed by carbendazim 12% + mancozeb 63% (12.23%) and tebuconazole 50% + trifloxystrobin 25% WG (15.05%) compared to unsprayed plot (70.21%) respectively. Correspondingly, the maximum capsule yield of 733.33 kg/ha was recorded in propiconazole 25 EC treated plot followed by 603.70 kg/ha in carbendazim 12% + mancozeb 63% and 588.89 kg/ha in tebuconazole 50% + trifloxystrobin 25% WG respectively. Whereas, minimum grain yield of 418.52kg/ha was recorded in untreated control plot.

Efficacy of fungicides on *Exserohilum turcicum* under *in vitro* conditions

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Maize is one of the important cereal crops of India. Maize is cultivated under diverse environmental conditions. As the maize cultivation reaches its boom in terms of acreage by adoption of modern crop production practices it also led the maize crop vulnerable to pest and diseases. Among the foliar diseases affecting maize, turcicum leaf blight is of worldwide importance. For managing the foliar diseases use of fungicides is a common practice. As *Exserohilum* is air borne pathogen and developed resistant to many of the fungicides. Total of 13 new fungicides were screened under *in-vitro* to know its efficacy against *Exserohilum turcicum*. Among the systemic fungicides, tebuconazole completely inhibit the pathogen growth at all the concentrations tested. In contact fungicides, propineb was highly effective as it inhibited the *E. turcicum* up to 83.89 per cent at 500 ppm and among combi products only carbendazim 12% + mancozeb 63% at 500ppm showed complete inhibition of the mycelial growth of *E. turcicum* and tebuconazole 50% + trifloxystrobin 25% was able to inhibit the mycelial growth up to 89.72 per cent at similar concentrations. By this study we can conclude that the tebuconazole, propineb, carbendazim 12% + mancozeb 63% and tebuconazole 50% + trifloxystrobin 25% were effective in inhibiting the mycelial growth of *E. turcicum* under lab conditions further it should be confirmed by testing under field conditions.

Effect of fungicides on powdery mildew of grapes

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An experiment was conducted to know the efficacy of fungicides against powdery mildew of grapes during 2014-15 at Honnakatti, Bagalkot, Karnataka. Results of the experiment revealed that, there was significant difference among the treatments. Results of Per cent Disease Index (PDI) on leaf recorded maximum reduction of disease (85.70%) was recorded in case of azoxystrobin @ 0.65ml/l with the PDI of 8.33 after 2nd spray. This treatment was followed by triademifon @1g/l. which recorded (82.84%) reduction over control after 2nd spray with the PDI of 10.00 and benomyl @ 0.3g/l (79.98%) reduction with the PDI of 11.67. Whereas, wettable sulphur @ 3gm/l recorded PDI of 13.33 and was found on-par with the proquinazid (20%EC) @0.25/l by recording 16.67 PDI. Whereas, in control, the disease index was increased from 43.33 to 58.33 from first to second spray period. With respect to bunch the maximum reduction of disease was recorded in case of azoxystrobin @ 0.65ml/l with the PDI of 3.33 after 2nd spray with the maximum yield (18.03). This treatment was followed by triademifon @1g/l. which recorded 82.63% reduction over control after 2nd spray with the PDI of 6.67 and yield of 16.30 followed by benomyl @ 0.3g/l which recorded 78.30% reduction with the PDI of 8.33. Whereas, wettable sulphur @ 3gm/l and proquinazid (20%EC) @0.25/l have shown on par results with respect to PDI (8.33 & 13.33) and yield (16.07 & 14.57). Whereas, in control the disease index was increased from 28.33 to 38.33 from first to second spray period and Yield of 10.06.

In vitro evaluation of systemic fungicides against *Phytophthora parasitica*, causing wilt in betel vine

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Betel vine is referred as green gold of India, because of its economic importance. This vital crop of India has found to be threatened by many pest and diseases. Among which *Phytophthora parasitica* the incitant of wilt disease in betel vine is a highly destructive pathogen causing death of the plant which leads to the drastic reduction in yield. To combat this pathogen we have made an effort to evaluate systemic fungicides viz., cymoxanil 8% + mancozeb 64%, fosetyl-Al 80 WP, tebuconazole 25.9% EC, dimethomorph 50 WP at 100, 500 and 1000 ppm using PDA as basal medium applying poisoned food technique. The results revealed that all the fungicides were found fungistatic and significantly inhibited mycelial growth of the test pathogen over untreated control. Among these, tebuconazole 25.9% EC has found more effective and recorded 100% inhibition at all the 3 concentrations. Followed by fosetyl-Al, dimethomorph 50 WP and cymoxanil 8% + mancozeb 64% have shown mean inhibition of 65.55%, 44.44% and 35.19% respectively over the control.

Management of foliar diseases of soybean through new fungicide molecules

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Foliar diseases especially rust and *Alternaria* blight are real threat to soybean cultivation. In order to manage these diseases a field experiment was carried out over two years at Agricultural Research Station, Nippani during *kharif* 2015 and 2016. Totally, seven treatments were included along with untreated check. Simple randomized block design was followed with four replications. Fungicidal treatments were imposed soon after the appearance of the diseases. Second spray was given 20 days after first spray. Disease observations were taken 80 days after sowing. During 2015 the data reveals that, the *Alternaria* leaf spot caused by *Alternaria* spp. and rust caused by *Phakopsora pachyrhizi* incidence was maximum in untreated check and maximum control of both the diseases were observed in the treatment viz., tebuconazole 430 SC @ 258 a.i., (g)/ha followed by tebuconazole 430 SC @ 215 a.i., (g)/ha. Highest grain yield of 25.23 q/ha was harvested in the treatment with tebuconazole 430 SC @ 258 a.i., (g)/ha which was significantly superior with all other treatments tested. Next best grain yield was recorded in the treatment with tebuconazole 430 SC @ 215 a. i., (g)/ ha. In the next year the data reveals that, the *alternaria* leaf spot and rust incidence was optimum in untreated check and maximum control of both the diseases were observed in the treatment viz., tebuconazole 430 SC @ 258 a.i., (g)/ha followed by tebuconazole 430 SC @ 215 a.i., (g)/ha. Highest grain yield of 22.33 q/ ha was harvested in the treatment with tebuconazole 430 SC @ 258 a.i., (g)/ha which was significantly superior with all other treatments tested. Next best grain yield (20.44 q/ha) was recorded in the treatment with tebuconazole 430 SC @ 215 a.i., (g)/ ha. By considering the two years data (2015 and 2016) it was clearly indicated that the foliar spray of tebuconazole 430 SC @ 258 a.i., (g)/ha showed good control of rust as well *Alternaria* leaf spot disease with considerably higher yield.

Efficacy of azoxystrobin against *Alternaria porri* incitant of purple blotch of onion

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The systemic fungicides viz., azoxystrobin, tebuconazole, difenconazole, propiconazole, carbendazim, thiophanate methyl and azoxystrobin 11 % + tebuconazole 18.3% SC were evaluated at 0.1, 0.15 and 0.2 per cent concentration against *Alternaria porri*, which causes purple blotch of onion under *in vitro* condition. Among the evaluated fungicides, azoxystrobin 11 % + tebuconazole 18.3 % SC was highly effective at 0.1, 0.15 and 0.2 per cent concentrations with the maximum per cent inhibition of 98.11, 100 and 100, respectively. This was found to be significantly superior over all the other treatments. Field experiment was also carried out to know the efficacy of azoxystrobin 11% + tebuconazole 18.3% SC at 500, 750 and 1000 ml/ha against purple blotch of onion. This fungicide at 1000 ml/ha significantly reduced the disease with the PDI of 31.00 followed by the dose at 750 ml/ha (34.00 PDI) and recorded yield of 21.91 and 21.31 t/ha, respectively as compared to the maximum PDI (81.00) and minimum yield (10.04 t/ha) in control.

Residue analysis of newer fungicidal molecule Azoxystrobin 8.3 % w/w + Mancozeb 64.7 5 w/w and management of anthracnose of grapes

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Grapevine occupies sixth position among the fruits produced in India. Pest occurrence in grapevine can make viticulture uneconomic and can have drastic effects on wine quality unless controlled. They include insects, nematodes, diseases (bacteria, fungi, phytoplasma, viroids and virus) and animals. Among the fungal diseases, downy mildew (*Plasmopara viticola*). Anthracnose (*Elsinoe ampelina*) is the most destructive and explosive disease of grapevine. The field trial conducted during August –January (2011-2012) at Theenampalayam village of Coimbatore district in Tamil Nadu indicated that azoxystrobin 8.3 % w/w + mancozeb 64.7 5 w/w @ 1500 g/ha (or 500 ml/ha) dose can effectively control on anthracnose of grapes. Average initial deposition of azoxystrobin was in the range of 0.38 to 0.16 and 0.67 to 0.29 mg kg⁻¹ and for mancozeb in the range of 2.50 to 1.19 and 4.17 to 1.98 mg kg⁻¹, given at respective doses. Residues of azoxystrobin and mancozeb were dissipated to the below detectable limit 7 days after spray at recommended dosage in all the locations.

Evaluation of Azoxystrobin 120 + Tebuconazole 240 SC against paddy blast

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Blast (*Pyricularia oryzae*) is considered the principal disease of rice because of its wide distribution and high incidence under favourable conditions and causes approximately 80 per cent yield loss. Hence, an effective management of crop is required by proper fungicides with right dosage. So, the experiment was laid out with replicated plots to know the effect of new molecule azoxystrobin 120 + tebuconazole 240 SC on the blast of rice during *Kharif* 2016 -17. The BPT-5204 rice variety was used by adopting all standard agronomic practices for the crop. The different doses of test fungicides were applied as foliar spray just after the appearance of blast disease with 15 days intervals and observation for disease incidence were recorded before as well as after each spray from the randomly selected ten hills per plot. Observation was recorded on the basis of scoring of the diseases as per the disease rating scale of SES, IRRI, (2002). Among the treatments, azoxystrobin 120 + tebuconazole 240 SC @ 830 ml/ha and azoxystrobin 120 + tebuconazole 240 SC @ 676 ml/ha were found to be the best treatments as there were 3.11 PDI and 4.44 PDI of leaf blast disease with higher grain yield of 62.50 and 60.80 q/ha recorded, respectively as compared to 26.50 PDI of leaf blast disease with grain yield of 39.60 q/ha in untreated control.

Efficacy of Azoxystrobin 120 % + Tebuconazole 240 % SC on incidence of sheath blight of rice

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Sheath blight (*Rhizoctonia solani*) is considered to be an important disease next to rice blast. Hence, an effective management of crop is required by proper fungicides with right dosage. So, the experiment was laid out with replicated plots to know the effect of new molecule azoxystrobin 120% + tebuconazole 240% SC on the sheath blight of rice during *Kharif* 2016-17. The BPT-5204 rice variety was used by adopting all standard agronomic practices for the crop. The different doses of test fungicides were applied as foliar spray just after the appearance of blast disease disease incidence were recorded before as well as after each spray from the randomly selected ten hills per plot. Lowest sheath blight disease intensity (5.74 PDI) was recorded in the treatment of azoxystrobin 120 + tebuconazole 240 SC @ 830ml/ha insignificantly with grain yield of 62.50 q/ha followed by in azoxystrobin 120 + tebuconazole 240 SC @ 676/ha (7.00 PDI) with yield potential of 60.80q/ha as compared to un treated control (35.33 PDI) with grain yield of 39.60 q/ha. Both these treatments were found significantly superior to rest of the treatments and provided higher reduction in disease incidence.

Soil and foliar application of sulphur for the management of linseed (*Linum usitatissimum* L.) powdery mildew (*Leveillula taurica* (Lev.))

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Powdery mildew of linseed (*Linum usitatissimum* L.) caused by *Leveillula taurica* (Lev.) is one of the major plant pathological constraints in successful linseed crop cultivation. Dropping of flowers and chaffy seed setting leads to serious loss in the linseed production. Keeping this in view, an attempt has been made to manage the disease by exploiting cheaper and effective sulphur through soil and foliar application. The pooled results of the two seasons field experiment showed that, out of eight treatments, experimental plots with two sprays of wettable sulphur (0.4%) (Sulphex) recorded minimum per cent disease index (PDI) of 13.50 with maximum yield (555 kg ha⁻¹) and BC ratio (2.68) which was significantly superior over all the treatments. The next best treatment was soil application of sulphur (30 kg ha⁻¹) through gypsum at the time of sowing followed by two sprays of 0.3 per cent wettable sulphur (Sulphex) (PDI -18.5, Yield -526 kg ha⁻¹ and BC ratio 2.44).

A novel fungicide for the management of sheath blight disease of paddy

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A new fungicide of BAS 750 02 F 400 g/l SC was tested in different doses against rice sheath blight disease under field conditions during *Kharif* 2015 and *Rabi* 2015-16. The test fungicide BAS 750 02 F 400 g/l SC at 300-350 ml/ha was found effective against sheath blight disease recording least percent disease index (PDI) of 14.45 and 16.32 respectively during *Kharif* 2015 and *Rabi* 2015-16. Compared to BAS 750 02 F 400 g/l SC, other test fungicides such as hexaconazole 5% SC at 1000 ml/h and propiconazole 25% EC at 500 ml/ha recorded highest PDI against sheath blight in both *Kharif* 2015 and *Rabi* 2015-2016. Significant increase in grain yield (57.37 q/h) was observed in the plots treated with test chemical BAS 750 02 F 400 g/l SC in *Kharif* 2015 and 60.35 q/ha during *Rabi* 2015-16, whereas, other fungicidal treatments recorded the yield in the range of 42.35-55.17 q/h (*Kharif* 2015) and 43.35-59.23 (*Rabi* 2015-16).

Novel fungicides for management of false smut disease of rice caused by *Ustilaginoidea virens*

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False smut caused by *Ustilaginoidea virens* is becoming a major disease of rice causing yield loss throughout the rice growing countries. In India, the disease has spread widely in recent years. In the present study nine fungicides were evaluated against the false smut disease of rice. Among the different fungicides tested at different concentrations *in vitro*, azoxystrobin (18.2 %) SC + difenconazole (11.4 %) SC @ 0.1 per cent, metiram (55 %) WG + pyraclostrobin (5 %) WG, tebuconazole 250 EC @ 0.1 per cent, flusilazole (25 %) SE + carbendazim (12.5 %) SE @ 0.1 per cent, and propiconazole 25 EC @ 0.1 per cent showed better efficacy and enhanced the paddy yield under field condition.

Management of thrips and purple blotch in onion

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Onion is one of the most important commercial vegetable cash crops grown in India and world, is severely affected by thrips and purple blotch. The experiments were conducted in farmer's field to know the effective spray schedules of fungicide and insecticide to manage both insect and disease. The schedules followed were consisting first spray of lambda-cylothrin @ 1ml mixed with mancozeb + carbendazim @ 2g/l followed by second spray of dimethoate @ 1.7ml mixed with difenconazole 1ml/l and third spray of carbosulfan @ 2ml mixed with chlorothalnil @ 2g/l. This integrated schedule (9.1 PDI) resulted in reduction of 43.83 per cent disease over farmers practice (16.2 PDI) and thrips population of less than 3/plant over control (7/plant). Due to lack of availability of water to growing tissues tip burning and bending problem increased in association with thrips and blotch incidence. Hence, irrigation schedule at soil crust formation or soil cracking time was strictly followed. The good bulb vigour maintained with soil application of *Trichoderma* enriched FYM as basal dose and also which minimizes upto 52 per cent avoidable yield loss.

Field evaluation of bio-efficacy and phytotoxicity of difenoconazole 10% + mancozeb 50% WDG against fruit rot, die back and powdery mildew diseases of chilli (cv. Byadgi dabbi)

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A field study was conducted at Horticultural Research and Extension Station, Devihosur to test the efficacy of difenoconazole 10% + mancozeb 50% WDG (new molecule) against fruit rot and powdery mildew diseases of chilli (Cv. Byadgi dabbi) with nine treatments and three replications. Difenoconazole 10% + mancozeb 50% WDG @ 1300 g/ha (0.26 %) recorded significantly least per cent disease index for fruit rot (8.51 PDI), die back (5.18 PDI), powdery mildew (8.51 PDI) and it was found on par with difenoconazole 10% + mancozeb 50% WDG @ 1000 g/ha (0.20 %). The test fungicide @ 1300 g/ha recorded significantly highest dry yield of chilli (8.29 q/ha) without any symptoms of phytotoxicity.

Field evaluation of bio-efficacy and phytotoxicity of fluxapyroxad 250 g/l + pyraclostrobin 250 g/l against fruit rot and powdery mildew diseases of chilli (cv. Byadgi dabbi)

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A field study was conducted at Horticultural Research and Extension Station, Devihosur to test the efficacy of fluxapyroxad 250 g/l + pyraclostrobin 250 g/l (new molecule) against fruit rot and powdery mildew diseases of chilli (cv. Byadgi dabbi) with nine treatments and three replications. Fluxapyroxad 250 g/l + pyraclostrobin 250 g/l @ 300 ml/ha (0.06 %) recorded significantly least per cent disease index for fruit rot (7.4 PDI) and powdery mildew (8.51 PDI) and it was found to be on par with fluxapyroxad 250 g/l + pyraclostrobin 250 g/l @ 250 ml/ha (0.05 %). The test fungicide @ 300 ml/ha recorded significantly highest dry yield of chilli (8.41 q/ha) and highest net returns (Rs.80,915/ha). No phytotoxicity symptoms were observed at all stage of the crop growth by the application of test chemical.

Tebuconazole 430SC a promising molecule to manage leaf spot and powdery mildew diseases of chilli

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Chilli (*Capsicum annuum* L.) is one of the major cash crops of India and several diseases are reported to cause lower productivity. Among them leaf spot (*Cercospora capsici*) and powdery mildew (*Leveillula taurica*) are the major foliar fungal diseases contributing 25-30% yield loss. Experiment was conducted during Kharif 2017-18 at Main Agricultural Research Station, UAS, Dharwad to test the efficacy of tebuconazole against both leaf spot and powdery mildew pathogens of chilli. The result revealed that, tebuconazole @500ml/ha has considerably reduced both leaf spot (12.72%) and powdery mildew (20.44%) diseases as compared to other recommended fungicides. The maximum leaf spot (24.77%) and powdery mildew (28.41%) disease severity was recorded in the untreated control plots. The reduced severity of both these disease has reflected on recording higher green chilli yields of 7.86t/ha as compared to untreated control plots which has recorded yields of 5.49t/ha. Thus, new molecule tebuconazole 430SC @500ml/ha can be used to manage leaf spot and powdery mildew diseases of chilli.

Evaluation of fungicides for the management of rot diseases of small cardamom (*Elettaria cardamomum* Maton.)

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India is known as the land of spices and among the spices grown in India, *Elettaria cardamomum* (small cardamom) is an important spice crop not only in terms of production and export but also in having centre of diversity in the evergreen forests of Western Ghats. Many rot diseases are affecting these crops and causing considerable crop loss. Capsule rot and rhizome rot of *E. cardamomum* are major diseases threatening the cultivation of cardamom results in 40 to 50 % of crop losses. The rot diseases of cardamom are managed through plant sanitation coupled with copper fungicidal application. The field trial was conducted at Indian Cardamom Research Institute, Myladumpara, Idukki District, Kerala for two years. This experiment was laid out in randomized block design RBD with and three replications. The fungicides such as dimethomorph 50WP (0.2%), cymoxanil 8 + mancozeb 64 WP (0.2%), hexaconazole 5EC (0.2%), iprovalicarb 5.5 + propineb 61.25 WP (0.2%), tebuconazole 25 EC (0.2%), potassium phosphonate (0.3%), fosetyl-Al 80WP (0.2%), COC 50WP (0.2%) + Bordeaux mixture (1.0%) and hexaconazole 2 + potassium phosphonate 16SC (0.2%) were used in this experiments. Before onset of the monsoon, plant sanitation work was completed. All the fungicides were sprayed in a monthly interval for three rounds except copper oxychloride. This copper fungicide was drenched in the plant base @ 2 – 5 liters depends the size of the clump. The incidence of rot diseases such as capsule rot and rhizome rot of cardamom was recorded periodically. Results showed that the incidence of diseases significantly was reduced in the plot treated with fungicides as compared to control. However, it was also observed that highest reduction of capsule rot and rhizome rot were noticed in the plot treated with as dimethomorph 50WP (0.2%), fosetyl-Al 80WP (0.2%) and COC 50WP (0.2%) + B.M. (1.0%) followed by other treatments. The highest yield also was recorded in these treatments. Based on the availability and cost of these fungicides, any one of these fungicides may be used for the management of capsule rot and rhizome rot diseases of small cardamom.

Evaluation of fungicides and varietal resistance for the management of leaf blight disease of cardamom

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Leaf blight of cardamom incited by the fungal pathogen *Colletotrichum gloeosporioides* has become a major and wide spread leaf disease in major cardamom growing regions of South India. Attempts were made to find out the best suitable fungicide and varietal resistance for the management of leaf blight in arecanut intercropping system. Among the fungicides tested, hexaconazole, propiconazole @ 0.1 % and mancozeb @ 0.25 % were found to be more effective in leaf blight disease management followed by carbendazim. The plants treated with hexaconazole were consistently recorded less disease intensity of 10.50, 9.30 and 11.40 percent during 2011, 2012 and 2013 respectively. Other fungicides copper hydroxide did not show better performance and recorded higher disease intensity. Among the cardamom varieties field evaluated for the disease resistance to leaf spot and leaf blight under natural infection condition showed differential reaction. The varieties CL-730 (9.80%) and CL-726 (10.53%) recorded less average leaf spot disease intensity. Other varieties recorded comparatively higher disease intensity ranged from 11.33 to 13.93 percent. However, CL-730 and Green Gold varieties were consistently found tolerant to leaf blight and showed less disease intensity. Other three varieties i.e., CL-722, CL-726 and Mudigere-3 showed moderate disease intensity. Remaining varieties viz., Mudigere-1 and Mudigere-2 were recorded comparatively higher disease intensity and are susceptible to leaf blight. As availability of suitable sources of resistance is a basic tool for the breeder, information generated from the study is useful in successful resistance breeding programmes and formulating the better chemical method of disease management.

Bio-efficacy of new fungicide molecules against early blight disease of tomato caused by *Alternaria solani*

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Early blight (*Alternaria solani*) disease is the most economically important and destructive foliar disease in tomato hampering the yield considerably. All the commercially cultivated hybrids/varieties are susceptible to this disease and therefore, this is primarily managed by use of foliar fungicides. However, frequent and continuous use of the fungicides has led to the development of fungicidal resistance against this disease. Keeping this in view, a field experiment was conducted *Kharif* season of 2015-16 to evaluate the new fungicide molecules like fluxapyroxad + pyraclostrobin (at 4 different dosages viz., 0.03, 0.04, 0.05 and 0.06 %), pyraclostrobin (0.1 %), fluxapyroxad (0.4 %) and commonly used fungicides like propineb (0.3 %) and copper hydroxide (0.25 %) against this disease. Among different fungicides, the fungicide fluxapyroxad + pyraclostrobin (0.06 %) with per cent disease index (PDI) of 2.67 was most effective followed by the same fungicide at different dosages of 0.05, 0.04 and 0.03 per cent with PDI of 8.00, 10.87 and 12.00 compared to the other fungicides fluxapyroxad, pyraclostrobin, propineb and copper hydroxide and control (33.33 PDI). Maximum yield (30.33 t/ha) was also realized in fluxapyroxad + pyraclostrobin (0.06 %) treated plot followed by in the plots treated with same fungicide at different dosages of 0.05, 0.04 and 0.03 per cent with yield of 29.10, 27.13 and 25.83 t/ha and the least yield (23.97 t/ha) was recorded in control plot.

Identification of alternate fungicides for the management of Carbendazim resistance in *Fusarium* species causing wilt in gladiolus and marigold

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Fusarium wilt in gladiolus and marigold causes huge economical losses to the growers. *Fusarium* species enter through the roots and blockwater conducting xylem vessels of the plant. As the infection spreads into the stems and leaves it restricts water flow causing the foliage to droop and whole plant to wilt. The plants turn yellow and after complete drying turn brown. The management practices generally employed to control fusarial wilts include use of resistant cultivars, chemical applications, cultural practices and biological strategies. The mainly used chemical is carbendazim. Recently *Fusarium* species are developing resistance towards carbendazim, which is more commonly used chemical fungicide to control *Fusarium* wilt in gladiolus and marigold. In the present study, evaluation of alternate fungicides was attempted for the management of carbendazim resistance in *Fusarium* isolates causing wilt in marigold and gladiolus. Carbendazim resistance isolates of *Fusarium* were used to test the efficacy of different fungicides like chlorothalonil (0.2%), captan (0.2%), bitertanol (0.2%), pyraclostrobin (0.1%), propiconazole (0.1%), azoxystrobin (0.05%), mancozeb (0.2%) and tebuconazole (0.1%). Plants treated with carbendazim (0.1 and 0.2%) were maintained for comparison. Disease incidence and colonization of roots by *Fusarium* at 45, 55, 65 and 75 days after inoculation were recorded. The results showed that in gladiolus, chlorothalonil, propiconazole and azoxystrobin were highly effective to control *Fusarium* wilt and recovery of the pathogen population also indicated the complete reduction of inoculum. In marigold, chlorothalonil, propiconazole, captan, bitertanol, tebuconazole and pyraclostrobin were effective. The use of alternative fungicides will help not only in the management of *Fusarium* wilt in marigold and gladiolus but also the carbendazim resistance in the selective populations by reducing their inoculum level in soil over a period of time.

Bio-efficacy and phytotoxicity of fluopyram 200 + tebuconazole 200 - 400 SC against postharvest diseases *Botrytis*, *Aspergillus* and *Penicillium* and shelf life management in grapes

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The bio-efficacy of fluopyram 200 + tebuconazole 200 - 400 SC against postharvest diseases in grapes was carried out during 2014-15 and 2015-16 at Regional Agricultural Research Station, Vijayapura. The treatment fluopyram 200 + tebuconazole 200 - 400 SC @ 525 ml/ha recorded less mean per cent discoloured grapes (12.98) followed by treatment i.e., fluopyram 200 + tebuconazole 200- 400 SC @ 450 ml/ha. The observation of post harvest pathogens viz., *Botrytis*, *Aspergillus* and *Penicillium* were recorded as per cent disease incidence. The treatment fluopyram 200 + tebuconazole 200 - 400 SC @ 625 ml/ha recorded less mean per cent disease incidence (7.34) followed by treatment i.e., fluopyram 200 + tebuconazole 200 - 400 SC @ 525 ml/ha (7.68). There was 81.25 per cent fruit loss in the control treatment, whereas, in the treatment imposed with fluopyram 200 + tebuconazole 200 - 400 SC @ 450, 525 and 625 recorded 22.50, 21.25 and 16.25 per cent of fruit loss respectively. There was no any phytotoxic or other harmful effects observed in any of the treatments under the evaluation of the test product (fluopyram 200 + tebuconazole 200 - 400 SC@125+125g a.i./ha, 250+250g a.i./ha and 500 + 500g a.i./ha) with respect to leaf chlorosis, leaf tip burning, leaf necrosis, leaf epinasty, leaf hyponasty, vein clearing, wilting and rosetting either on the foliage or fruits of grape.

Evaluation of fungicides for the management of dry root rot of groundnut caused by *Rhizoctonia bataticola*

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Groundnut is the most important oilseed crops in the world. Soil borne diseases are most destructive and wide spread group of diseases in groundnut. Among them, dry root rot of groundnut caused by *Rhizoctonia bataticola* has gained economic importance in north eastern Karnataka. Hence a study was undertaken to screen different fungicides against *R. bataticola* employing poison food technique. Among the different fungicides tested, irrespective of fungicide concentration, carbendazim inhibited maximum radial growth (100.00%) at all the concentration (0.15%, 0.1% and 0.15%) under *in vitro* test, followed by pyraclostrobin (98.06 %) and tebuconazole (97.06). Least mycelial inhibition of 88.55 and 89.30 per cent was exhibited by propiconazole and hexaconazole respectively.

Scheduling of fungicides for the management of late blight disease of potato caused by *Phytophthora infestans* (Mont.) de Bary

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Potato (*Solanum tuberosum* L.) belonging to the family *Solanaceae*, is the most important food crop stands fourth position after paddy, wheat and maize. Chemical control remains the most important control measure against late blight. Growing potatoes without using fungicides has become unthinkable in most parts of the world. The control strategy is primarily preventive but in case the pathogen infects the crop, the epidemic must be stopped by using more powerful formulations. While, using the fungicide there is a problem of development of resistance against fungicides due to repeated spraying of fungicides with same mode of action. The present results on fungicide scheduling for the management of late blight disease revealed that, late blight disease severity was significantly reduced by spraying of fungicides in sequence at weekly intervals. Among the different combinations of fungicide schedules, the spray sequence of mancozeb followed by mandipropamid, dimethomorph + mancozeb followed by mancozeb at weekly intervals for four times found highly effective in managing the disease and recorded least disease incidence of 44.51 % compared to control gives maximum reduction of both disease incidence 76.16 percent over control (100 %) and disease severity of 3.10 per cent over control (28.98 per cent) respectively. This schedule also recorded maximum tuber yield of 15.8 t ha⁻¹ compare to control (11.80 t ha⁻¹). The second best spray schedule is spraying of mancozeb, mandipropamid, fenamidone + mancozeb and mancozeb at weekly interval compare to other spray schedules and control.

Bio-efficacy and standardization of dosage of GPF 715 + GPF 116 (Tank mix) against *Turcicum* leaf blight of maize

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Maize is an important coarse cereal crop growing both as food for man and feed for animals throughout the world. Although area under cultivation is more, the crop suffering from various diseases viz., *Turcicum* leaf blight, brown leaf spot, common rust, *Curvularia* leaf spot and stalk rot etc. Among these, *Turcicum* leaf blight is an important disease of maize in Karnataka causing considerable yield loss. The present study on bio efficacy and standardization of dosage of GPF 715 + GPF 116 (Tank mix) against TLB was carried out under field condition during *Kharif* 2016 at Agricultural College, Bheemarayanagudi by using CP 818 maize hybrid. Among the 12 treatments evaluated, three dosage of combi product viz., T2- GPF 715 + GPF 116 (156 + 1400g/ha), T3- GPF 715 + GPF 116 (176 + 1575g/ha) and T4- GPF 715 + GPF 116 (196 +1750g/ha) were recorded least PDI (16.50, 12.70 and 10.75) on *Turcicum* leaf blight with highest grain yield of 62.75q/ha, 63.40q/ha and 63.72q/ha respectively. These treatments were on par with T11- Navio which recorded *turcicum* leaf blight PDI of 13.88 (21.87) with grain yield of 63.23q/ha. Whereas, untreated control recorded highest PDI of *Turcicum* leaf blight (40.85) with least grain yield (43.23q/ha). Over all tank mixed GPF715 + GPF 116 were superior in managing the disease compared to treatments alone.

Management of tuberose leaf blight disease caused by *Alternaria polianthi* in northern Karnataka

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Tuberose (*Polianthes tuberosa* L.) is one of the most important tropical aromatic flowering plants, most valued by the aesthetic world for their beauty and fragrance. It is commercially cultivated for cut and loose flower trade and also for the extraction of its highly valued natural flower oil. Recently the incidence of leaf blight disease caused by *Alternaria polianthi* is considered as a severe problem causing growth reduction and yield loss triggered by high temperature and humidity. Hence an investigation was carried out at Medicinal and Aromatic Garden, College of Agriculture, Hanumanamatti, Karnataka, to study the bio-efficacy of different fungicides against leaf blight of tuberose. Six fungicides viz., tebuconazole 250 EC @ 0.1 %, difenconazole – 25 % EC @ 0.1 %, propiconazole 25 % EC @ 0.1 %, hexaconazole 2 % SC @ 0.1 %, mancozeb 75 WP @ 0.25 %, chlorothalonil 75 WP @ 0.2 %, were evaluated in tuberose cultivar Prajwal during *kharif* 2014 to 2016. Among the different fungicides, three sprays taken with tebuconazole @ 0.1 % at 15 days interval starting from onset of disease proved to be the most effective treatment and resulted in lowest percent disease index, PDI (10.25) followed by propiconazole @ 0.1 % (11.25 PDI) as compared to control (34.30 PDI). Maximum yield, number of flower stalks per square meter area was recorded in tebuconazole @ 0.1% (51.50) followed by propiconazole @ 0.1 % (47.40) and the least yield was recorded in untreated control (26.50).

In vitro evaluation of combi- fungicides against major hemibiotrophic foliar fungal diseases of soybean

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Combi-fungicides were evaluated against hemibiotrophic foliar fungal pathogens (*Colletotrichum truncatum* (Schw.) Andrus and Moore, *Alternaria alternata* Keissler and *Cercospora sojina* Hara) of soybean through poisoned food technique. Among the four combi-fungicides tested at three concentrations (0.05 %, 0.1 % and 0.2 %) the maximum per cent mycelial inhibition was recorded with difenonazole 25 % + propiconazole 25 % EC at 0.1 and 0.2 per cent (100 %) followed by carbendazim 25 % + mancozeb 50 % WS at 0.20 per cent (100 %) and trifloxystrobin 25 % + tebuconazole 50 % WG at 0.20 per cent (94.81%). The least per cent mycelial inhibition was recorded with hexaconazole 5 % + captan 70 % WP (80.01 %) at 0.05 per cent concentration against *Colletotrichum truncatum*. Against *Alternaria alternata*, the maximum per cent mycelial inhibition was recorded with difenonazole 25 % + propiconazole 25 % EC at 0.2 (100 %) and 0.1 per cent (93.70 %) followed by carbendazim 25 % + mancozeb 50 % WS at 0.20 per cent (85.18 %) and trifloxystrobin 25 % + tebuconazole 50 % WG at 0.20 per cent (82.60 %). The least per cent mycelial inhibition was recorded in treatment with hexaconazole 5 % + captan 70 % WP (64.81%) at 0.05 per cent concentration. The maximum per cent mycelial inhibition was recorded in treatment with carbendazim 25 % + mancozeb 50 % WS at 0.2 and 0.1 per cent (100 %) followed by difenonazole 25 % + propiconazole 25 % EC at 0.20 per cent (100 %) and trifloxystrobin 25 % + tebuconazole 50 % WG at 0.20 per cent (100 %) against *Cercospora sojina*. Among the combi-fungicides evaluated difenonazole 25 % + propiconazole 25 % EC and trifloxystrobin 25 % + tebuconazole 50 % WG were found more effective compared to other treatments.

Bio efficacy of new combination fungicide Tricyclazole 45% + Hexaconazole 10% WG against neck blast disease of rice

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Blast disease caused by *Pyricularia oryzae* Cavara is one of the most widespread and devastating disease of rice worldwide. Neck and panicle blast is the most detrimental to yield. It is estimated that each year rice blast causes losses of 10-30 % of the global rice yield. In India 75% losses of grains was due to serious blast epidemics in India (Padmanabhan, 1965). In recent years the blast disease has become more severe and problematic in both *kharif* and *rabi* season in Cauvery command areas (Mandya and Mysuru) of Karnataka. Till date there are no resistant varieties for blast disease. Thus disease management using fungicides play crucial role as many popular high yielding varieties is susceptible to the disease. Although many existing fungicides are effective against the disease, indiscriminate use of the same chemicals may cause resistance development in the pathogen. Thus to identify alternate fungicide, a new combination fungicide tricyclazole 45% + hexaconazole 10% WG was evaluated along with other existing fungicides against neck blast of rice. An experiment was conducted using popular susceptible variety MTU1001 during *Kharif* 2014 and 2015 at ZARS, VC farm Mandya, Karnataka under field condition. The fungicide was sprayed at 5% panicle emergence stage. The results indicated the new combination product tricyclazole 45% + hexaconazole 10% WG (ICF-110) @1g/l was significantly effective in reducing the disease severity of neck blast with a PDI of 9.41 and yield of 6954 kg/ha as against a PDI of 63.83 and yield of 4061 kg/ha in untreated control. The new chemical did not show any symptoms of phyto-toxicity.

Evaluation of azoxystrobin 11%+tebuconazole 18.3% SC against early blight disease of tomato caused by *Alternaria solani*

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A field study was conducted to evaluate the bio-efficacy and phytotoxicity of azoxystrobin 11% + tebuconazole 18.3% SC against early blight of tomato at Agricultural Research Station, Kawadimatti, University of Agricultural Sciences, Raichur, Karnataka during the year 2014 and 2015. The polled results showed that the severity of the disease was lowest (18.82 PDI) azoxystrobin 11% + tebuconazole 18.3% SC @ 2ml/l was applied to the crop compared with untreated control. After third spraying, azoxystrobin 11% + tebuconazole 18.3% SC @ 2ml/l was statistically at par with azoxystrobin 11% + tebuconazole 18.3% SC @ 1.5 ml/l and the percentage of disease severity were 18.82 % & 19.85% respectively. The yield was significantly higher when azoxystrobin 11% + tebuconazole 18.3% SC @ 2ml/t sprayed plot (37.82 t/ha) followed by azoxystrobin 11%+ tebuconazole 18.3% SC @ 1.5 ml (38.38) and 1.5 ml of azoxystrobin 23% SC and 1.5 ml of tebuconazole 25.9% EC alone. No phytotoxicity symptoms were observed when a higher dose of fungicide was applied.

Bioefficacy and phytotoxicity evaluation of tetraconazole 3.8% EW against powdery mildew disease of mango caused by *Oidium mangiferae*

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Mango (*Mangifera indica*) is an important fruit crop of India and is being cultivated in many states throughout the country. Mango is known to be affected by several diseases. Among them, powdery mildew caused by *Oidium mangiferae* is a most common disease, occurs almost every year and causing significant yield losses. The pathogen attacks leaves, inflorescence and also on young fruits, causing fruit drop at button stage. For the evaluation of bio-efficacy and phytotoxicity of tetraconazole 3.8% EW against powdery mildew of mango, a field experiment was conducted with different concentrations consisting of 6 treatments with 4 replications in a RCBD at Horticulture Research Station, Hogalegere during 2014-15 and 2015-16 season and two sprays were given at 15 days interval. The lowest powdery mildew incidence was observed on Inflorescence with T₃-tetraconazole 3.8% EW @ 1500 ml/ha (11.11 PDI) and fruit yield of 5.70 t/ha for 15 days after spray. The results are on par with T₂-tetraconazole 3.8 % EW @ 1250 ml/ha (12.50 PDI) and fruit yield of 5.45 t/ha. These treatments were significantly at par with domark 3.8 % EW @ 1250 ml/ha (11.80 PDI) and fruit yield of 5.08 t/ha at 15 days after second spray. The same trend was observed during 2015-16 i.e., tetraconazole 3.8 % EW @ 1250 ml/ha (12.86 PDI) at 15 days after spray was highly effective for powdery mildew disease in mango with increased economic yield (6.38 t/ha) without showing any phytotoxicity on the plant.

In vivo management of foliar diseases of groundnut

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Groundnut crop is prone attack by numerous diseases to a much larger extent than any other crops. One of the most important factors contributing to low yield is disease attack. Among fungal foliar diseases, only a few are economically important in India such as leaf spots (early and late) and rust which are widely distributed can cause losses in susceptible genotypes to the extent of 70-80 percent when both of them occur together. Belatedly, *Alternaria alternata* leaf spot is becoming increasingly important on rabi/summer crop and also on kharif groundnut crop. In this context, a field experiment was conducted at MARS, UAS, Raichur during kharif 2016 to manage these foliar diseases by fungicides. The results revealed that T₄: Seed treatment with tebuconazole 2DS @ 1.5 g/kg seeds and foliar spray of tebuconazole 50% + trifloxystobin 25% WG @ 1.32 g/L (0.035%) at 40 and 65 DAS resulted in significantly lowest PDI for ELS, LLS, Rust and *Alternaria* leaf blight (9.38%, 23.64%, 18.63% and 6.22%) followed by T₃: (Seed treatment with tebuconazole 2DS @ 1.5 g/kg seeds and foliar spray of pyraclostrobin 5% + metiram 55% WG @ 2 g/L (0.12%) at 40 and 65 DAS i.e., 10.03%, 24.38%, 19.38% and 7.02% respectively). Significantly higher pod yield of 3080.5 kg/ha and haulm yield of 5028 was recorded in T₄ followed by T₃ (pod yield: 2984.5 kg/ha and haulm yield: 48965 kg/ha) and T₂ (pod yield: 2880.5 kg/ha and haulm yield: 4789 kg/ha).

Efficacy of metalaxyl-M4%+Mancozeb 64% WP against citrus gummosis

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Lime is an important fruit crop in Bijapur district next to grape. It occupies an area of 2302 hectares with the production is 57550 tons and productivity of 25 tons per ha. However, the yield of this crop in the district has been decreasing due to several reasons. Among many factors, gummosis disease caused by *Phytophthora spp.* is major one. The important disease symptoms are profuse gumming on the surface of the attacked bark. When gumming occurs on the stem, droplets of gum trickle down the stem. It gradually turns dark brown and develops longitudinal cracks. As a result of severe gumming, the bark becomes completely rotten and the tree dries owing to girdling effect. The survey reports revealed that in an individual affected garden, the yield loss is noticed upto 25-30%. For the control of this disease several fungicides have been tested in the farmer's field during 2007-08. Among them, 3.0g of Ridomil gold (metalaxyl-M 4%WP + mancozeb 64%WP) was found effective in checking the incidence (9.0 % PDI)and recorded higher yield (298 q/ha) followed by Allite (fosetyl-Al) @ 2.0 g (10.10 % PDI & yield of 280 q /ha) whereas in untreated control the disease incidence was 55.30 per cent and yield was 262 q per ha.

Picoxystrobin 25 SC, an effective eco-friendly new fungicide for the management of downy mildew of grapes

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Grape is one of the important fruits crops next only to citrus and is gaining importance in Indian horticulture. The quality and quantity obtained by the farmers in field situation is varied. Among several factors, diseases are of prime importance. Among many diseases noticed on the grape, the downy mildew caused by *Plasmopara viticola* (Schw.) Burr. is becoming major constraint and cause considerable quantitative and qualitative losses of grape production in Northern Karnataka. In recent years, strobilins groups of fungicides have been introduced for the management of this disease.The new fungicide product picoxystrobin 25SC was assessed for its bio-efficacy against downy mildew of grape during productive pruning periods during the years 2008-09 and 2009-10 in the Atalatti village of Bijapur district, Karnataka, India. The results revealed that, the new fungicide product, picoxystrobin 25 SC @ 100 g a.i./ha (i.e., 0.5 ml/l) was found equally effective to as that check fungicide metalxyl MZ 8 % WP (Ridomil Gold 8 % WP) @ 2 g/l in reducing the severity of downy mildew of grape and thereby increasing the fruit yield. The results of pooled analysis of two years data indicated that, picoxystrobin 25 SC @ 100 g a.i./ha was found to be superior with lowest disease of 9.65 PDI at 10 days of third spray and was on par with the metalaxyl MZ 72 WP @ 2 g/l (9.85 PDI) and picoxystrobin 25 SC @ 100 g a.i./ha (8.5 PDI). In untreated control plot the downy mildew pressure was 71.84 PDI. Significantly higher fruit yield of 18.34 t/ha was noticed with picoxystrobin 25 SC @ 100 g a.i./ha which is on par with the fruit yield of 18.07 t/ha was recorded with the check cymoxanil 8 % + mancozeb 64 % WP @ 2.5 g/l and 19.68 t/ha in picoxystrobin 25 SC @ 125 g. a.i. In untreated control significantly lowest least yield was noticed (7.09 t/ha). There were no phytotoxic effects such as leaf epinasty, hyponasty and wilting etc even at higher concentrations of picoxystrobin 25 SC @ 100 g a.i./ha @ 125 g.a.i. Hence, picoxystrobin 25 SC @ 100 g a.i./ha can be used as an effective component in development of spray schedule for the management downy mildew of grape.

Technical Session IX

Integrated disease management approaches

Integrated approach to manage early blight disease of tomato

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Tomato (*Lycopersicon esculentum* Mill) is one of the most popular and widely grown vegetable crops in India and throughout the world. Many factors operate in successful cultivation as well as marketing of quality tomato, of which diseases play an important role. Among the fungal diseases, early blight incited by *Alternaria solani* is one of the world's most catastrophic disease causing loss from 50 to 86 per cent in fruit yield in tomato growing tracks of India, so also in Karnataka.

Experiment was conducted during Kharif 2017-18 at Main Agricultural Research station, UAS, Dharwad to test the efficacy of *Pseudomonas fluorescens* (SUDO) against early blight disease. The results revealed that, the plots sprayed with Difenconazole (0.1%) followed by *Pseudomonas fluorescens* @ 0.5% at 15 days interval has resulted in lower disease severity (11.88%) which is found on par with spray with *Pseudomonas fluorescens* @ 0.5% - mancozeb @ 0.2% (13.09%) followed by spray with sectin @ 0.3% - *Pseudomonas fluorescens* @ 0.5% (14.82%). However, two sprays with sectin have significantly lowered the disease severity (9.88%). However, two sprays with *Pseudomonas fluorescens* have recorded 28.34 per cent disease severity which is recorded to be significantly superior as compared to untreated control (42.40%). Thus, *Pseudomonas fluorescens* a potential biocontrol agent can be used as a component in early blight disease management of tomato.

Integrated management of downy mildew in cucumber caused by *Pseudoperonospora cubensis*

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Downy mildew, caused by fungi *Pseudoperonospora cubensis*, is one of the most destructive pathogen for successful cultivation of cucumber. The losses caused by this pathogen depends on growth stage at infection, rate of foliage growth and pathogen development. *Pseudoperonospora cubensis* outbreaks over the past several decades have been responsible for annual yield losses of up to 40%. The control of downy mildew disease has been almost exclusively based on the application of chemical fungicides. In this context, integrated approaches may help develop an eco-friendly control strategy for managing this disease. Considering the growing importance of the downy mildew disease and the lack of information on integrated management, the present study was undertaken to develop integrated approaches to manage this disease. Soil application of *Trichoderma harzianum* through farm yard manure (enrichment- 1kg / 100kg for 15 days followed by seed treatment with metalaxyl (2.0g/kg seeds) were found more effective in reducing development of the disease. Prophylactic spray – mancozeb (2.5 g/L) – 3 weeks after sowing followed by sprays of metalaxyl + mancozeb (2.0 g/L) and dimethomorph (1.0 g/L) + mancozeb (2.0 g/L) based on disease severity at 5th and 7th weeks after sowing lowered disease severity and better yields were recorded. Results of the investigation of effectiveness of fungicides and biocontrol agents to minimize the disease incidence of late blight of two years field trial (2015 and 2016) indicated that biocontrol agents and the systemic fungicides significantly reduced the disease severity and increased yield over control.

Development of integrated disease management module for late blight of potato

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Late blight caused by *Phytophthora infestans* (Mont.) de Bary is a serious disease of tomato and potato worldwide. Most of the cultivars grown in the world are reported to be susceptible to late blight. Presently, it is environmentally, economically and scientifically unacceptable to rely primarily on fungicides for disease control. Systemic fungicides have been used widely in the past, but the disease has developed resistance over time. Considering the growing importance of the late blight disease and the lack of information on integrated management, the present study was undertaken to develop integrated approaches to manage this disease. These approaches were cultural controls such as manipulation of date of sowing and minimal use of fungicides and use of bio-control agents. The present investigation was carried out to evaluate the efficacy of different fungicides and biocontrol agents to combat the disease. Soil application of *Trichoderma harzianum* and *Pseudomonas fluorescens* through farm yard manure (enrichment- 1kg / 100kg) 15 days before transplanting followed by tuber treatment with mancozeb (2.0g /kg). prophylactic spray with mancozeb (2.5 g/L) 5 weeks after planting followed by sprays of fenamidone + mancozeb (3.0 g/L), iprovalicarb + propineb (4.0 g/L) and dimethomorph (1.0 g/L) + mancozeb (2.0 g/L) based on disease severity at 7th, 9th and 11th weeks after planting depending on the disease severity considerably reduced late blight progress, with a corresponding increase in tuber yield. Statistical analysis indicated that the results were highly significant. Both fungicides and bio-pesticides provided better control of the disease in the treated plots than in the control plots.

Evaluation of different seed treatment methods for the management of mungbean (*Vigna radiate* L.) seed mycoflora

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Mungbean is the third most important pulse crop among the food legumes grown in India. It is grown principally for its protein content. Seed borne mycoflora associated with mungbean carried over from year to year and from one place to another with the seeds which serve as primary source of infection for subsequent crops. Management of seed borne mycoflora has been reasonably achieved through fungicides and biological agents. Seed treatment is one of the important methods in the integrated management of any disease and has provided excellent results in reducing losses caused by mycoflora with increase in quality and quantity of seed.

To manage the seed mycoflora of mungbean different seed treatment methods were evaluated. Hot water treatment at 40° C for 30 minutes was found best in managing seed mycoflora followed by dry heat treatment 45° C for one hour and solar heat treatment. Out of seven fungicides tested, seed treatment with captan at the rate 4 g kg⁻¹ of seed significantly reduced seed mycoflora (78.68 %). Seed treatment with *Trichoderma harzianum* at the rate of 8 g kg⁻¹ of seed reduced the seed mycoflora up to (69.63 %) followed by *Pseudomonas fluorescences* (66.49 %) and *Trichoderma viride* (64.39 %).

Varietal assessment and management of chickpea wilt through fungicide and bio pesticides

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The chickpea is the most important *Rabi* crops of North Karnataka. Different varieties viz., JG-11, JG-14 and Annigeri were evaluated to know the *Fusarium* wilt incidence in Kalaburgi during 2015-16 and 2016-17. The result showed that, incidence of wilt varied between the varieties from 4.0 to 17.5 per cent. Among the varieties, least wilt incidence (4.0 %) was recorded in JG-11 followed by JG-14 (5.5 %) and higher incidence (17.5 %) was noticed in Annigeri. The experiments was undertaken to know the effect of fungicides and bio-agents on wilt and its pathogen in variety Annigeri. Among the fungicides tested *in vitro* against the wilt pathogen, only two chemicals viz., carbendazim and carbendazim + mancozeb in higher concentration proved to be the most effective as they inhibited (100 %) the fungus growth completely. Whereas, carboxin, captan, metalaxyl and thiophanate methyl were found to be next best in inhibiting the growth of the pathogen ranging from 83 to 90 per cent. In field condition, maximum seed germination was observed in carbendazim seed treatment (91.0 %) with very less wilt incidence (7.1 %) along with higher grain yield (12.6 qt/ha). Maximum wilt incidence was noticed in metalaxyl seed treatment (32.21 %) with lower germination percentage (80.0 %) and yield (9.2 qt/ha). Among the bio-agents tested both *in vitro* and *in vivo*, *Trichoderma* was found to be best. In field condition, treatment resulted with lower incidence of wilt (6.7 %), higher seed germination (95.0 %) and yield (12.9 qt/ha).

Management of major soil borne diseases of groundnut under field condition

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Field experiment was conducted to study the effect of different fungicides and bioagents as seed dresser as well as soil application of bioagents enriched in farm yard manure against major soil borne diseases of groundnut (Var- TMV₂) during *kharif* 2016. The observations on disease incidence were recorded at 30 DAS, at flowering and at harvest stage and pod yield were recorded and analyzed. The experimental results revealed that all treatments imposed during the experiment were efficient in managing the major soil borne diseases (collar rot, stem rot and dry root rot) and improved pod yield compared to untreated control. Less incidence of collar rot, stem rot and dry root rot was shown in T₁₀ with disease incidence of 3.90 per cent, 7.33 per cent and 6.74 per cent respectively followed by T₁₁, with disease incidence of 5.51 per cent, 7.59 and 7.61 per cent respectively. On an average imposition of only bioagents (T₃) or only fungicides (T₄) showed the disease incidence of 9.27 per cent and 9.23 per cent of collar rot, 12.63 per cent and 11.70 per cent of stem rot and 21.72 per cent and 18.59 per cent of dry root rot incidence respectively which was higher than the T₁₀ and T₁₁. The highest pod yield (22.99 q ha⁻¹) was noticed in T₁₀ *i.e.* seed treatment with tebuconazole 1 g kg⁻¹ + soil application of consortium (*Trichoderma* + *Pseudomonas*) enriched in every 250 kg FYM ha⁻¹ at 35-40 DAS followed by T₁₁ (22.68 q/ha) *i.e.*, seed treatment with sprint 3 g kg⁻¹ + soil application of consortium (*Trichoderma* + *Pseudomonas*) enriched in every 250 kg FYM ha⁻¹ at 35-40 DAS and the disease incidence was statistically significant in untreated plot(10.42 q ha⁻¹).

Achievements in sea weed bio- molecules in respect to plant disease management

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Seaweeds are salt water dwelling marine algae that are red, brown and green coloured depending on their pigment content. Seaweeds constitute a rich source of polymers, vitamins, hormones, essential fatty acids, minerals, antimicrobial and antiviral agents, thus offering a wide range of therapeutic possibilities, both against plants and human infections (Cooksley, 2007). Carrageenans are extracted from red algae (*Kappaphycus alvarezii*) known as sulfated galactans, are linear polysaccharides and composed by repeating dimers of α -1,4-D-galactose linked by alternated bonds of α -1,3 and α -1,4 and substituted by one (ϵ -carrageenan), two (ϵ -carrageenan) or three (ϵ -carrageenan) sulfate ester groups within each repeating unit. The application of carrageenan triggered different defense systems involving ethylene, jasmonic acid and salicylic acid pathways. Induction of resistance by ϵ -carrageenan in *Arabidopsis thaliana* (L.) against *Sclerotinia sclerotiorum* was due to an increase in oxalate oxidase activity and is related with the expression of jasmonic acid signaling associated genes, e.g., AOS, PDF1.2 and PR3.

Laminarans are reserve polysaccharide found in brown algae (*Laminaria digitata*) stimulate defense reactions in tobacco, grapevine and rice by activating protein kinase, Ca^{2+} influx, oxidative burst and alkalization of extracellular media resulted increase of chitinase and α -1,3-glucanase, phytoalexins production and expression of PR-proteins. All these happens because the oligosaccharides obtained from laminaran mimics pathogen attack. Similarly, Ulvans are heteropolysaccharides extracted from green algae *Ulva* (Sealettuce) acts as elicitor on beans which could reduce the severity of diseases, such as rust (*Uromyces appendiculatus*), anthracnose (*Colletotrichum lindemuthianum*) and powdery mildew (*Erysiphe polygoni*) by inhibiting mycelial growth, conidial germination of fungus *in vitro* and *in vivo* and *Uromyces appendiculatus* by increasing the peroxidase activity occurred at 72 h after infection .

Treatment with increasing concentrations of oligo-carrageenans enhanced protection against TMV, *Botrytis cinerea*, *Pectobacterium carotovorum*, *Phytophthora megasperma* indicating a long-term protection that mimics vaccination. Furthermore, oligo-carrageenans induced a sustained activation of phenylalanine ammonia lyase activity and the accumulation of phenylpropanoid compounds with potential antimicrobial activities suggesting these compounds are involved in protection and suppression effects.

Integrated management of rhizome rot of banana cv. grand naine (AAA)

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An experiment was conducted during 2012-13, 2013-14 and 2015 at K.R.C. College of Horticulture, Arabhavi, UHS, Bagalkot. There were eleven treatments, each treatment was replicated three times with a randomized block design. A susceptible cultivar Grand Naine was planted with a spacing of 1.8x1.8m. Results revealed that, disease free suckers from disease free field+dipping in Copper oxychloride @ 4g/lit +Streptocycline @ 0.3g/lit for 45min. followed by drenching with Copper oxychloride @ 3g/lit + Streptocycline @ 0.3g/lit for three times at 30 days interval effectively controlled the rhizome rot disease (3.70%). The next best treatments were healthy suckers+ drenching with Streptocycline 1 liter per plant @ 500 ppm (15 days, 2nd month, 4th month after planting) + growing sunhemp in the interspaces till 6 months after planting (12.03%), healthy suckers + dipping in streptocycline for 30 min @ 500 ppm (13.89%), healthy suckers+ soil application with 6g bleaching powder 5 times at monthly intervals up to 4 MAP (months after planting) + drenching with streptocycline 1 lit /plant (500ppm) at 1st MAP+ *Trichoderma viride* (50g/plant at 2nd, 4th MAP) + growing sunhemp in the interspaces till MAP (20.37%) and healthy suckers+ drenching with *Pseudomonas fluorescens* 1 lit/plant @ 50gm per liter of water 5 times at monthly interval + growing sunhemp in the interspaces till 6 months after planting (24.07%). The highest incidence (37.03%) was recorded in healthy suckers. With regards to yield in the year 2012-13 indicated that, the highest yield (78.95t/ha.) was recorded in the treatment of disease free suckers from disease free field + dipping in copper oxychloride @ 4g/lit + streptocycline @ 0.3g/lit for 45 min followed by drenching with copper oxychloride @ 3g/lit + streptocycline @ 0.3g/lit for three times at 30 days interval. The next best treatments were healthy suckers + drenching with streptocycline 1 liter per plant @ 500 ppm (15 days, 2nd month, 4th month after planting) + growing sunhemp in the interspaces till 6 months after planting (71.49t/ha) and healthy suckers+ dipping in streptocycline for 30 min @ 500 ppm (68.11t/ha).

Bio-intensive management of thrips transmitted bud blight disease of tomato

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In the recent years, tomato is being grown extensively in Karnataka and it suffers from fungal, bacterial and viral diseases. Among the viral diseases, bud blight disease of tomato caused by *Peanut Bud Necrosis Virus* (PBNV) transmitted by thrips is a serious problem in north eastern Karnataka. In order find a solution to this problem a field experiment was conducted during *Kharif* 2014 at MARS Raichur, with different chemical schedule which included new chemical molecules, bio agent and botanicals. Among the different chemical schedule, the best schedule was T5 (seedling dip with imidachloprid 17.8 SL at .03ml/l - *P. fluorescens* @ 5g/l - thiamethoxam 0.2 g/l - Neemoil (1500 ppm) @ 5 ml/l at 15 days interval from planting). Followed by T6 (seedling dip with imidachloprid 17.8 SL @ .03ml/l- *P. fluorescens*@ 5g/l - dinotefuron 20 SG @ 0.2 g/l- Neemoil (1500 ppm) @ 5 ml/l at 15 days interval from planting) with the disease reduction of 50.00 per cent and 45.99 per cent respectively and a yield of 29.12 t/ha and 26.03t/ha respectively.

Management of wilt and collar rot in pigeon pea

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Pigeon Pea is an important pulse crop of Tumkur district which is grown in an area of 13,317 ha with the productivity of 3.77 q/ha. Major constraints for pigeon pea growers of the district are intermittent drought, pod borer and wilt caused by *Fusarium* and collar rot caused by *Sclerotium*. Farmers have substantial difficulty in managing the disease as their understanding about the disease process is limited

In order to overcome wilt and collar rot in pigeon pea effectively an on-farm testing was conducted under farmer's field with the following technology capsules - Seed treatment with carbendazim @ 3g/kg seeds, and seed treatment with carbendazim + mancozeb (SAAF) @ 3g/kg seeds followed by *Trichoderma* @ 6g/kg seeds and farmer practice.

Among the treatments seed treatment with carbendazim + mancozeb (SAAF) @ 3g/kg seeds followed by *Trichoderma* @ 6g/kg seeds recorded 13.4 q/ha with 10 % wilt and 2.5 per cent collar rot disease incidence with 2.31 BC ratio compare to farmer practice of no seed treatment where an yield of 8.5 q/ha with 33 % wilt and 8.4 per cent collar rot disease incidence with 1.68 BC ratio was recorded. Further, results of the technology was disseminated to other farmers through on and off campus trainings, demonstrations involving extension methodologies of KVK to improve farmers ability to understand disease management process.

In vitro* evaluation of fungicides, botanicals and bio-agents against *Alternaria porri

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Onion (*Allium cepa* L.) is one of the major bulb crop in India, and it is widely cultivated species of genus *Allium* belonging to the family Alliaceae. Purple blotch of onion caused by *Alternaria porri* (Ellis) cif. is one of the most destructive disease causing heavy loss under field conditions. To know the efficacy of different fungicides, botanicals and bio-agents, were tested under *in-vitro* condition. Mancozeb 75 WP was effective in controlling the mycelial growth of *A. Porri* with per cent mean inhibition of (97.68 %), followed by difenconazole 25 EC (95.75 %). Among the five botanicals tested, garlic (84.51%) was significantly superior over all other plant extracts evaluated. The next best treatment was pongamia leaf extract (80.81%) and Neem (74.32%). *In-vitro* evaluation of bio-agents revealed that *T. harzianum* isolate 1 (83.10%) which was significantly superior over other isolate tested. Least inhibition was noticed in *Pseudomonas fluorescens* isolate 1 (51.52%).

Integrated management of root knot nematode, *Meloidogyne graminicola* in rice

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In Karnataka, rice (*Oryza sativa* L.) is one of the most important cereal crops and it is also a staple food of nearly half of the state population. It is grown under different agro-climatic regions irrespective of soil types, different cultivars, rain fall and temperature with different cultivation systems viz., drill sown, SRI method, irrigated and submerged rice in different parts of state. In some areas, only one crop is grown and in certain other areas, three crops are raised. The unique feature of rice culture in the state is that either sowing or transplanting is seen in all seasons of the year. Of late, rice root-knot nematode, *Meloidogyne graminicola* has emerged as a major threat throughout the world due to its adoptable nature, broad host range and ability of causing potential yield loss. The losses caused by *M. graminicola* may vary from 16-80 %. It is a serious problem in the nurseries and upland rice but has been found to be widespread in the deepwater and irrigated rice also in many states of India. The existing condition is highly congenial for *M. graminicola* in Karnataka and it is attaining alarming situation and spreading rapidly in both nurseries and main fields in almost all major rice growing districts.

Rice root-knot nematode appeared in devastating form in parts of major rice growing areas of Shivamogga during 2001, which was a first report from Karnataka and subsequently reported from Mandya district of the state. Initially, it was noticed only in aerobic condition. Since 2011, it is appearing in anaerobic condition also and appearing in all types of rice cultivating situations. A survey of the state revealed that all the districts are infected with rice root-knot nematodes, however, their level of incidence differs in different districts. Among the districts, more severe incidence of root-knot nematode was observed with root knot index of 5 in Shivamogga and 4 in Chickmagalur, Mandya and Hassan districts. Moderate infection was noticed in districts of Davanagere, Dakshina Kannada, Udupi, Uttar Kannada, Mysuru, Kodagu and Haveri with root knot index of 3, whereas, the northern districts of Karnataka shows least root-knot index of 1 where the type of soil was black or vertisols. Thus, there is an indication that the district with gall indices varying from 1 to 3 may become future hotspots, as, the climate prevailing in those districts and more area coming under irrigation and tendency to grow rice after rice are creating congenial conditions. Hence, there is a need to create awareness among farming community. The nematode appears to be adopting itself to different soil conditions and climatic conditions as deviation from its typical gall formation pattern of hook like or club shaped galls at the tip of the root as per the available literature.

The degree of symptom manifestation depends on several factors, viz., time of infection, age of the plant and load of inoculum. Abiotic factors such as nutrition, temperature, soil type, moisture etc., play an important role on nematode population. Indiscriminate use of chemicals for managing this disease results in the development of nematode resistance and risk to the soil environment. Ecofriendly approaches such as, removal of host weeds, flooding of fields, summer ploughing, organic amendments, use of effective biocontrol agents and resistant cultivars has some advantage in managing the disease.

Soil solarisation of nursery beds for 15 days and application of carbofuran 3G at 15g/m² to the nursery for effective management of root-knot nematode (Ravindra, 2006). Khan *et al.*, (2012) reported that root-dip and soil application of phorate 10G (25 mg a.i.,/pot), carbofuran 3G (83.3mg a.i.,/pot), carbosulfan 20EC (5l/pot) and chlorpyrifos 20 EC (6.25 l/pot) reduces root-knot infestation in rice. Somasekhara *et al.*, (2012) showed that the adoption of INMT (Integrated Nematode Management Technology) resulted in reducing the nematode population from 320 J₂/200 cc soil as initial nematode population to 135 (Carbofuran (0.3 g a.i./m²) (T₁), 165 (*P. fluorescens* at 20 g/m²) (T₂) and 192 (*T. viride* at 4 g (T₃)/200 cc of soil and also increases yield by 4.72 tonnes/ha, 4.67 tonnes/ha and 4.29 tonnes /ha in T₁, T₂ and T₃ respectively, in comparison to 3.81 tonnes/ha in untreated control (T₄). Integrated nematode management study was conducted in Assam, the pooled data of five years showed that carbofuran treated nursery bed had 100 galls/20 seedlings, *P. fluorescens* and *T. viridae* had 115 galls/20 seedlings and 118 galls/20 seedling. 29.6% and 28.6% yield increased in carbofuran and *P. fluorescens* treated plots (Seghal *et al.*, 2014). Narasimhamurthy *et al.* (2016) showed that, treatment combination of *P. fluorescens* at 20g/m² + carbofuran (0.3 g a.i./m²) recorded highest plant height (83.26 cm), root length (20.60 cm), maximum grain yield (44.1 q/ha) and least nematode population (132.67/200g soil).

Status and management of pomegranate diseases in Karnataka

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Pomegranate (*Punica granatum* L.) is a high value fruit-bearing deciduous shrub belonging to family puniceae. It is being grown since ancient times for its fruit, ornamental and medicinal purposes. It is indigenous to Iran and is cultivated extensively in Spain, Morocco Egypt, Iron, Afghanistan, Arabia and other Mediterranean countries.

In India, pomegranate is commercially cultivated in Maharashtra, Karnataka and small scale plantations are seen in Gujarat, Rajasthan, Tamilnadu, Telangana, Andhra Pradesh, Punjab and Haryana. Being a highly remunerative crop, it is gaining popularity in other states of India also. In Karnataka fifteen years back no major diseases causing economic losses were reported on pomegranate with remunerative returns from small area and the growing demand in export and local market, growers adopted new improved varieties and hi-tech horticulture. As a result some of the diseases, which were practically unknown or of little economic importance are reported to be a serious problem, today. Due to occurrence of rains, high humidity and temperature during the growing season the plants are more vulnerable to various diseases resulting in high losses to the farmers of the Karnataka state. So far large number of diseases have been reported to affect pomegranate plant roots, leaves, stem, branches twigs and fruits.

Among various diseases of pomegranate bacterial blight/oily spot (*Xanthomonas axonopodis* pv. *punicae*) and wilt (*Ceratocystis fimbriata* and *Fusarium oxysporum*), anthracnose, Pestalotia leaf spot, spha celoma scab and root knot nematode (*Meloidogyne incognita*) has been recorded from almost all the pomegranate growing areas of Karnataka. The anthracnose disease incidence on fruits was recorded from 22.72 to 31.81 per cent The wilt caused by *Ceratocystis fimbriata* with an incidence ranging from 16.42 to 32.17 per cent bacterial blight incidence was also recorded. The Root-knot nematode index was recorded ranging from 2.1 to 4.0. For management of the disease various components of IDM was used for managing important diseases of pomegranate in field condition.

Management of purple blotch disease of onion under field condition

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Onion (*Allium cepa* L.) is one of the oldest known and an important vegetable crop grown in India. Productivity of onion is affected by many biotic and abiotic stresses. Among the biotic stresses, diseases play an important role and among them, purple blotch caused by *Alternaria porri* is one of the most destructive disease. The study was conducted to check the efficacy of different fungicides and bio-agents under field condition. The results revealed that among the chemicals difenconazole 25 EC (Score) @ 0.1 % was found effective in reducing the disease with a per cent disease reduction over control of (62.23). Among the bio-agents tested *Trichoderma harzianum* was found effective with the per cent disease reduction over control of (54.47) followed by treatment with a combination of *Trichoderma harzianum* and *Pseudomonas flourosceus* (41.91).

Management of *Alternaria* blight of sunflower through bio-agent and fungicides

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Biological control of plant pathogens through antagonistic microorganisms is a potential, ecofriendly and alternative to the chemical management of diseases. *Alternaria* blight is an important destructive disease of sunflower commonly managed using chemicals. Hence, an attempt was made to manage *Alternaria* blight through bio agents and fungicides. All the treatments tried were significantly effective in reducing the severity of *Alternaria* leaf spot. At 50 per cent grain filling stage, the severity of *Alternaria* leaf spot varied from 25.00 to 76.25 per cent. In T₃ (Seed treatment with *Pseudomonas fluorescense* @ 10g/kg seed followed by spray of Propiconazole @ 0.1% at 45 and *P. fluorescense* @1.0% at 60 days after sowing) the severity of *Alternaria* leaf spot was lowest (25.00%) . The next best treatment was T₁- Seed treatment with *Pseudomonas fluorescense* @ 10g/kg seed followed by 2 sprays of *P. fluorescense* @ 1.0% at 45 and 60 days after sowing with disease severity of 33.5 per cent .The disease severity was 76.25 per cent in control. The yield was significantly superior over control in all the treatments, T₂ (Seed priming (carbendazim 2 g/kg seeds + thiomethoxam @ 0.04 %) + spray of propiconazole @ 0.1% +thiomethoxam @ 0.04% as soon as disease appears and 15 days later), T₃ (Seed treatment with *Pseudomonas fluorescense* @ 10g/kg seed followed by spray of propiconazole @ 0.1% at 45 and *P.fluorescense* @1.0% at 60 days after sowing) and T₄ (Seed priming (carbendazim 2 g/kg seeds + thiomethoxam @0.04 %) + spray of propiconazole @ 0.1% + azadarictin @ 1.5 ml/l as soon as disease appears and 15 days later) were on par in inducing systemic resistance against *Alternaria* leaf blight.

Evaluation of components for integrated management of important diseases of sunflower

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Sunflower (*Helianthus annuus* L.) is an important oil seed crop and when introduced during early 1970s was free from diseases. The popularity of the crop among farmers resulted in larger area under the crop many diseases have co-evolved with sunflower. *Alternaria* blight emerged as a major threat in the cultivation during late 1980's. During 1997 sunflower necrosis disease caused by tobacco streak virus belonging to Iilar virus group was reported. Severe foliar (80%) infections by powdery mildew were observed during 2006 at Challakere and Chitradurga districts in Karnataka. In all, the diseases in sunflower have reported an average of 25-40 per cent yield loss (Shankergoud *et al.*, 2006). In the present investigation, field evaluation of various components for integrated management of important diseases of sunflower was conducted for three consecutive years 2013-14 to 2015-16. In the pooled data all the treatments reduced the disease significantly compared to the unsprayed control. T₂ (Seed treatment with *Pseudomonas fluorescense* @ 10g/kg seed followed by spray of hexaconazole @ 0.1% at 45 and *P. fluorescense* @1.0% at 60 days after sowing) recorded the least disease severity of *Alternaria* leaf spot (19.9%) which was significantly superior over all the other treatments. T₁ and T₃ with disease severity of 26.00 and 28.33 per cent respectively were on par with each other. The necrosis virus disease was least in T₁ (Seed bioprimering with *Trichoderma viridae* @ 10g/kg seed +spray of propiconazole @ 0.1% +thiomethoxam @ 0.04% as soon as disease appears and 15 days later) treated plots which was on par with T₂. In the pooled data highest seed yield was recorded in T₁ which was significantly superior over other treatments.

Integrated management of *Fusarium* and *Sclerotium* in blackpepper

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Black pepper nursery is inflicted by an array of soilborne plant pathogens of which *Fusarium* and *Sclerotium* are the most devastating causing 100% crop loss. A study was conducted at Pepper Research Station, Panniyur to assay the effect of chemicals and biocontrol agents (*Trichoderma viride* and *Pseudomonas fluorescens*) against the above pathogens. The pathogens were isolated from the infected plants in the pepper nursery and its pathogenicity was proved. The morphological characters were studied and the pathogens were identified as *Fusarium solani* and *Sclerotium rolfsii*. *In vitro* inhibition of the pathogens against the fungicides was tested by poisoned food technique. The fungicides tested were contact (copper oxy chloride, Bordeaux mixture and copper hydroxide), systemic fungicides (carbendazim, hexaconazole and propiconazole) and combination fungicide (carbendazim and mancozeb) at recommended, higher and lower doses. Among the different fungicides assayed, effective ones for the management of *Fusarium* and *Sclerotium* were Bordeaux mixture, hexaconazole, propiconazole and carbendazim+mancozeb. The above fungicides at recommended and higher doses were effective in reducing the mycelial growth of the pathogen. Copper oxychloride and copper hydroxide were ineffective in managing the pathogens. The systemic fungicide carbendazim had a negative effect on the pathogens and has promoted growth of bacteria. The biocontrol agents tested had antagonistic activity against *Fusarium* and *Sclerotium*. The mycelial growth of the tested pathogens were effectively suppressed by the over growth of *Trichoderma*. *Pseudomonas fluorescens* also inhibited the mycelial growth of the pathogens by antibiosis.

Management of bacterial leaf blight of rice caused by *Xanthomonas oryzae* pv. *oryzae* under field condition

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Bacterial leaf blight (BLB) is considered as a major threat to paddy production because of its wide spread, distribution and its destructiveness under favourable conditions. The disease is caused by *Xanthomonas oryzae* pv. *oryzae* is one of the most destructive disease in irrigated and rainfed environment in Asia and cause considerable loss. Chemicals are the important components for mitigating the plant diseases. Hence, commercially available antibiotics and other antibacterial chemicals were evaluated against the disease. The biocontrol agents are also equally important in disease management. Thus, a field trial was conducted during *Kharif* 2016 at AHRS, Bavikere to know the efficacy of different commercially available antibacterial chemicals and bio-agents against the bacterial leaf blight of rice. Results indicated that, streptomycin @ 0.5g/l+ copper oxychloride @ 2.5g/l treated plots showed the lowest per cent disease incidence of 22.33 per cent followed by bacterinashak @ 0.5g/l, agrimycin 100 @ 0.2g/l and kasugamycin @ 2 ml/l and the highest disease severity was recorded in control (55.53%). Highest grain yield of 56.49 q/ha was recorded in streptomycin + copper oxychloride, which was significantly superior over all other treatments, followed by bacterinashak (54.24 q/ha), kasugamycin (50.13 q/ha) and agrimycin 100 (49.38 q/ha). The least grain yield was obtained in *Bacillus subtilis* (41.33 q/ha).

Management of PBNB through integration of different strategies

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Two season field experiment was conducted during summer 2014 and 2015 on management of PBNB through integration of different strategies. Three different modules were framed and compared with farmers practice and control plots. The PBNB incidence was not noticed eventhrough the thrips population was good enough when the crop was 20 days old. However, 4 to 5 per cent PBNB was noticed when crop was 27 days old in farmers practice plot and control plot respectively during 2014 Similarly, 3 to 4 per cent was noticed during summer 2015. Whereas, no incidence was noticed in the plots where modules were imposed. There after the incidence of PBNB was gradually increased in all the treatments with differential incidence. Among the different modules, Module II comprising of Border crop with bajra (4 rows)+Seed treatment with Gaucho 480 Fs @1ml/kg seed + Foliar sprays using Thioclopid 480 Fs @ 150 ml / ha at 20-25 DAS followed by Fipronil 5SC @1ml/lit @ 40DAS and Acetamaprid 20 SP @ 100 g/ha at 60 DAS was found effective in reducing PBNB with the maximum disease incidence of 4 and 7 per cent only during 2014 and 2015 respectively with 22 and 24 number of thrips population in 10 terminal buds of the groundnut during a week before harvest as compared to control plot where the disease incidence of 14-18 percent with the average number of thrips population was 65-69 respectively during 2014 and 2015. The module also supported higher yield 10.63 q/ha in 2014 and 11.56 q/ha in 2015 as against to control plot. (9.40 q/ha).

Integrated management of rhizome rot complex disease of ginger in Uttara Kannada district

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The field experiment was conducted at Banavasi (Sirsi taluk) and Jade village (Sorabha taluk) during 2016-17 with different combination of chemicals and bio-agents to test their efficacy against fungal (*Pythium* sp. and *Fusarium* sp.) and bacterial (*Ralstonia solanacearum*) wilt complex. The results showed that pre-sowing application of FYM enriched with *Trichoderma arzanum* @ 2kg/200 kg + FYM enriched with *Pseudomonas fluorescens* @ 5kg/ 200 kg + FYM enriched with *Bacillus subtilis* @ 2kg/ 200 kg + Neem cake @ 1q/ acre + Pre-sowing soaking of rhizomes with 0.05 % streptomycin + 0.3 % Ridomil gold (metalaxyl + mancozeb) for 10 minutes followed by drenching with 0.2% bleaching powder and 0.3 % Ridomil gold (metalaxyl 4% + mancozeb 64%) thrice at 20 days intervals from disease inception found highly effective in reducing the PDI (13.67%). The next best was Pre- sowing soaking of rhizomes with 0.3 % Apron 35 SW (metalaxyl) for 10 minutes followed by drenching with 0.1 % Acrobat (dimethomorph 50% WP) and 0.05 % K-cyclin + 0.3 % copper oxychloride immediately after onset of disease after disease inception in reducing PDI (16.00 %). Maximum disease incidence was noticed in untreated control (48.67%) depicting the essentiality of bactericide + fungicide as seed and soil drench in disease suppression.

Integrated management of chilli powdery mildew incited by *Leveillula taurica* (Lev.) Arn.

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Powdery mildew of chilli incited by *Leveillula taurica* (Lev.) Arn. is a devastating disease of chilli. In the present investigation, management of powdery mildew disease was undertaken during 2015-16 by the application of fungicides, bioagents and botanicals under field conditions. Among the twelve treatments, myclobutanil (0.1 %) spray was found most effective in reducing the disease severity (PDI 17.37) followed by triadimefon (PDI 20.70) and hexaconazole (PDI 23.75) compared to control (PDI 88.24) respectively. The bioagents, *Pseudomonas fluorescens* (PDI 61.14) and *Trichoderma harzianum* (PDI 63.79) and the plant extracts viz., *Azadiracta indica* (PDI 62.56) and *Allium sativa* L. (PDI 63.54) were found less effective in reducing the disease severity as compared to fungicidal treatments respectively. Further, myclobutanil and triadimefon recorded higher dry chilli yield of 12.72 and 12.27 q/ha. The highest cost: benefit ratio was obtained in myclobutanil (1:2.43) sprayed plots followed by triadimefon (1:2.39) respectively. In the present study, the fungicide myclobutanil and triadimefon were found superior in reducing the chilli powdery mildew disease severity which remain on par with each other and thus helped for getting highest dry chilli fruit yield and B:C ratio.

Efficacy of fungicides and bioagents against *Colletotrichum gloeosporioides* causing anthracnose of mango (*Mangifera indica* L.)

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Mango (*Mangifera indica* L.) commonly called as “King of fruits” is the most important fruit crop in India. Among the various diseases, anthracnose, caused by *Colletotrichum gloeosporioides* (Penz.) Penz and Sacc. is the major constraint on extension of export of mango. Therefore efforts were made to screen the different systemic and combination of six fungicides, *in vitro*. Among systemic fungicides, propiconazole 25 per cent EC was successful in completely (100 %) inhibiting the growth of *C. gloeosporioides* at all four concentrations (0.025, 0.05, 0.1 and 0.15 %). Thiophanate methyl 70 per cent WP and tebuconazole 25 per cent EC gave 100 per cent mycelial inhibition at three (0.05, 0.10 and 0.15 %) concentrations and combination of fungicides carbendazim 12 per cent WP + mancozeb 63 per cent WP was found the most effective and gave cent per cent growth inhibition at all four concentrations (0.05, 0.1, 0.2 and 0.3 %). Among the biocontrol agents, *Trichoderma viride* (Tv-2) and *Trichoderma viride* (Tv-1) gave maximum inhibition of mycelial growth of 78.22 % and 75.92 % of *C. gloeosporioides* respectively.

Integrated management of turicum leaf blight of maize

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Maize is an important food and feed crop which ranks third after wheat and rice in India and the world. Because of its expanded use in the agro-industries it is recognized as a leading commercial cereal crop of great agro-economic value. Maize is cultivated under diverse environmental conditions. As the maize cultivation reaches its boom in terms of acreage, adoption of modern crop production practices like, using chemical fertilizers and chemical pesticides led the maize crop vulnerable to pests and diseases. Among the foliar diseases affecting maize, turicum leaf blight is of worldwide importance causing severe yield losses. So an integrated approach for the management of turicum leaf blight using different botanicals, bioagents and chemicals alone and in combination was carried out under field conditions in two seasons. Among the treatments tested, least per cent disease index was observed infoliar application of tebuconazole 50% + trifloxystrobin 25% @ 2 gL⁻¹ treated plots with 49.67 which was on par with foliar application of propiconazole @ 0.5 mL⁻¹ (51.33), seed treatment with *Trichoderma harzianum* @ 4g/kg + foliar spray of mancozeb @ 2 gL⁻¹ + foliar application of neem seed kernel extract @ 5 mL⁻¹ (51.67) and foliar application of tebuconazole 50% + trifloxystrobin 25% @ 0.5 gL⁻¹ (54.00). Whereas, maximum PDI was noticed in seed treatment @ 5 mL⁻¹ + foliar application of neem seed kernel extract @ 5 mL⁻¹ (65.67) and seed treatment with *Trichoderma harzianum* @ 4 g/kg + foliar spray of tebuconazole 50% + trifloxystrobin 25% @ 1 gL⁻¹ + foliar application of neem seed kernel extract @ 5 mL⁻¹ (65.67) treated plots.

Nematode problems in protected cultivation and management

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Polyhouse farming or protected cultivation is an alternative new technique of cultivation in horticulture gaining foothold in rural India. It reduces dependency on rainfall, makes maximum use of land and other resources to produce more. This farming can help the farmer generate income round the year growing multiple crops apart from providing a better income. The polyhouse is actually a 'disease factory'. The crops under such cultivation are prone to several pathogens including nematodes, which could reduce the quality and quantity of produce. The ideal and stable environment with warm, humid and abundant food under poly house provides an excellent platform for the development of nematodes often more than field conditions. Major vegetable and ornamental crops grown under protected cultivation are seriously affected by root-knot nematode (*Meloidogyne* spp.), lesion nematode (*Pratylenchus* spp.,) and spiral nematode (*Helicotylenchus* spp.,), among others. Root-knot nematodes are more frequently associated with polyhouse crops. Plants growing in nematode-infested soils usually are unthrifty, stunted, yellowish and have galled and decayed roots. Nematode infested plant roots are more susceptible to other diseases caused by fungi and bacteria, which leads to complex diseases and tend to stop producing early. In most cases, problems arise from contaminated soil or soil mixture used as a component of the growing medium, monocropping and infested planting materials. Nematode management must be considered primarily as exclusion or avoidance. Once nematodes are introduced it is difficult to manage them. Major strategies include drenching the soil with 0.5 per cent formalin at 100 ml/kg soil followed by covering with polythene tarps for two weeks before sowing/planting ; adding well decomposed farm yard manure at rate of 20 tons per hectare to enrich soil ; incorporating neem cake at 250 kg/ha soil two weeks before sowing/planting; applying *Purpureocellium lilacinum* / *Pseudomonas fluorescens* @ 2.5 kg/ha mixed with 50 kg farmyard manure ten days before sowing/planting ;use of nematicides like carbofuran 3G at rate of 1 kg./ha.

Exploring the role of WRKY1 in wild relative of tomato against *Alternaria solani*

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Wild relatives of crop plants harbour many potential plant defence genes. *Solanum arcanum* Peralta is a wild relative of *S. lycopersicum* L. (Tomato) showing robust resistance against plant pathogens. Current high yielding cultivated tomato varieties are vulnerable to early blight (EB) caused by *Alternaria solani* leading to 32- 79% yield loss in tropical and subtropical countries. As transcription factors including WRKY plays a major role in regulating host defence, aim of present research was to identify and functionally characterize pathogen induced WRKY genes from tomato. We identified eight WRKY genes which were induced either early or late stage of infection. Further, we analysed WRKY1, as a potential candidate gene during EB defense. EMSA confirmed binding of recombinant WRKY1 protein with W boxes in native promoters of key cell wall modification element (*XTH5*) and *MYB2*. Transgenic tomato plants over expressing WRKY1 showed elevated levels of *XTH5* and *MYB2* genes with significant reduction in EB disease symptoms compared to non-transgenic plants. These two targets of WRKY1 could have resulted in physical barrier formation by cell wall modification and transcriptional regulation of defence genes. Thus, present study indicated the potential role of WRKY1 in EB resistance for the first time and could be useful in designing future strategies to improve crop protection against EB.

In vitro evaluation of chemicals, botanicals, bio-agents and selected nutrients against *Xanthomonas axonopodis* pv. *betlicola* causing leaf spot in betel vine

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Betelvine (*Piper betle* L.) is a perennial dioecious creeper cultivated in India for its leaf since time immemorial. Bacterial leaf spot disease caused by *Xanthomonas axonopodis* pv. *betlicola* is prevalent in betel vine plantations. A little is known about the disease in changed agricultural situation, particularly in Karnataka. Present investigation relates to the identification of chemicals for its management. Among the antibiotics evaluated under *in vitro*, K-cycline was found effective against *X. a.* pv. *betlicola*, followed by streptomycin. Least inhibition was found in bromopol. Among the chemicals, Bordeaux mixture was found effective against *X. a.* pv. *betlicola*, followed by copper oxychloride. No inhibition was found in copper hydroxide. Among the antibiotics and chemicals in combination evaluated under *in vitro*, K-cycline in combination with COC was found effective against *X. a.* pv. *betlicola*, which was significantly superior to rest of the bactericides followed by streptomycin in combination with COC. Among bio-agents evaluated, *Pseudomonas fluorescens* was found very effective in inhibiting the growth of the pathogen followed by *Bacillus subtilis*. Among plant extracts tested, meswak extract was proved to be very effective in inhibiting the maximum growth of the pathogen followed by garlic extract. Among nine nutrients tested, CuSO₄ recorded highest mean inhibitory zone followed by ZnSO₄ and FeSO₄ at all concentrations tested.

Integrated management of rhizome rot complex disease of ginger

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Ginger (*Zingiber officinale* Rose) is an important commercial spice crops grown extensively in Malnad part of Karnataka. Among the production constraints, rhizome rot complex caused by a two different pathogens such as fungus, *Pythium aphanidermatum* and bacteria, *Ralstonia solanacearum*, which were responsible for reducing ginger production. Unchecked movement of seed material is found to be the factor for disease spread. The field study was carried out at four locations (2 each in Sirsi and Hanagal taluk) during 2015-16 with chemicals-bioagent combination for their efficacy against *Pythium* rot cum *Ralstonia* wilt complex prone ginger field. The experiment was laid in RCBD and imposed 9 treatments with 3 replications raised bed of 1.5 m (width) x 0.15 m (height) x 10 m (length) dimension /replication with 40 cm inter spacing between beds. The results showed that pre-sowing rhizome treatment with 0.05% K-cycline + 0.3 COC for 15 minutes + pre-sowing soil application with FYM enriched *Trichoderma harzianum* (@ 2 kg/ton FYM) + FYM enriched *Pseudomonas fluorescens* (@5 kg/ton FYM)+ neem cake (1qt/ac.) followed by drenching with 0.2% bleaching powder and 0.1% metalaxyl MZ (T_7) thrice at 20 days intervals from disease inception found highly effective in reducing the PDI(4.46). The next best was rhizome treatment with 0.05% streptomycin + 0.3% copper oxychloride for 15min. followed by soil drench with 0.2% bleaching powder and 0.1% metalaxyl MZ after disease inception (T_8) in reducing PDI (9.28). Untreated control exceeded 17 times the T_7 in PDI (58.39) depicting the essentiality of bactericide + fungicide as seed and soil drench in disease suppression. Regard to yield also, the treatment T_7 (as given above) indicated the boosting of yield (134.33kg/ha.) followed T_8 (106.23 kg/ha.).

Status and management of pomegranate diseases in Karnataka

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Pomegranate (*Punica granatum* L.) is a high value fruit-bearing deciduous shrub belonging to family *Punicaceae*. It is being grown since ancient times for its fruit, ornamental and medicinal purposes. It is indigenous to Iran and is cultivated extensively in Spain, Morocco, Egypt, Iran, Afghanistan, Arabia and other Mediterranean countries. In India, pomegranate is commercially cultivated in Maharashtra, Karnataka and small scale plantations are seen in Gujarat, Rajasthan, Tamilnadu, Telangana, Andhra Pradesh, Punjab and Haryana. Being a highly remunerative crop, it is gaining popularity in other states of India also. In Karnataka fifteen years back no major diseases causing economic losses were reported on pomegranate with remunerative returns from small area and the growing demand in export and local market, growers adopted new improved varieties and hi-tech horticulture. As a result some of the diseases, which were practically unknown or of little economic importance are reported to be a serious problem, today. Due to occurrence of rains, high humidity and temperature during the growing season the plants are more vulnerable to various diseases resulting in high losses to the farmers of the Karnataka state. So far large number of diseases has been reported to affect pomegranate plant roots, leaves, stem, branches twigs and fruits. A m o n g various diseases of pomegranate, bacterial blight/oily spot (*Xanthomonas axonopodis* pv. *punicae*) and wilt (*Ceratocystis fimbriata* and *Fusarium oxysporum*), anthracnose, *Pestalotia* leaf spot, *Sphaceloma* scab and root knot nematode (*Meloidogyne incognita*) has been recorded from almost all the pomegranate growing areas of Karnataka. The anthracnose disease incidence on fruits was recorded from 22.72 to 31.81percent The wilt caused by *Ceratocystis fimbriata* with an incidence ranging from 16.42 to 32.17 percent Bacterial blight incidence was also recorded. The root knot nematode index was recorded ranging from 2.1 to 4.0. For management of the diseases various components of IDM were used under field conditions.

Effect of combination of insecticides and neem based pesticide on growth and yield parameters of mungbean infected with MYMV

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To know the effectiveness of different insecticides as seed treatment and spraying under field conditions against mungbean yellow mosaic virus (MYMV) infecting mungbean (*Vigna radiata* L.), the experiment was conducted at ZARS, GKVK with two different sowings during 2016. There were totally seven treatments with different combinations. Randomly five plants from each treatment were collected (at harvesting stage) for assessing growth and yield parameters. The effect of MYMV on plant height, pods per plant and yield per ha was studied in each treatment and five plant average data was analysed statistically by combining values from both the sowings. Among seven treatments, seed treatment with imidachloprid 17.8 % SL at 5 ml/kg seeds along with two sprays of imidachloprid 17.8 % SL at 0.5 ml/l was found to be the best with 20.43 pods per plant which was followed by two sprays of imidachloprid 17.8 % SL at 0.5 ml/l alone and seed treatment with imidachloprid 17.8 % SL at 0.5 ml/l and two sprays of neemazal (5% azadirachtin) at 3 ml/l which recorded 18.73 and 16.12 pods per plant, respectively. Highest grain yield of 1017.50 kg/ha was recorded in seed treated with imidachloprid 17.8 % SL at 5 ml/kg seeds plus two sprays of imidachloprid 17.8 % SL at 0.5 ml/l and followed by 972.50 kg/ha in two sprays of imidachloprid 17.8 % SL at 0.5 ml/l alone. Seed treatment with imidachloprid 17.8 % SL at 5 ml/kg seeds along with two sprays of neemazal (5% azadirachtin) at 3ml/l was next best treatment (898.50kg/ha). At the end of each sowing period (70 days after sowing), no significant difference was observed between various treatments with regard to plant height.

In-vitro* evaluation of fungicides, botanicals and bio-agents against *Alternaria porri

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Onion (*Allium cepa* L.) is one of the major bulb crops in India, and it is widely cultivated species of genus *Allium* belonging to the family *Alliaceae*. Purple blotch of onion caused by *Alternaria porri* (Ellis) cif. is one of the most destructive diseases causing heavy loss under field conditions. To know the efficacy of different fungicides, botanicals and bio-agents, under *in-vitro* condition an experiment was conducted. Mancozeb 75 WP was effective in inhibiting the mycelial growth of *A. Porri* with per cent mean inhibition of (97.68 %), followed by difenoconazole 25 EC (95.75 %). Among the five botanicals tested, garlic (84.51%) was significantly superior over all other plant extracts evaluated. The next best treatment was pongamia leaf extract (80.81%) and neem (74.32%). *In-vitro* evaluation of bio-agents revealed that *T. harzianum* isolate 1 (83.10%) which was significantly superior over other isolate tested. Least inhibition was noticed in *Pseudomonas fluorescens* isolate 1 (51.52%).

Management of purple blotch disease of onion under field condition

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Onion (*Allium cepa* L.) is one of the oldest known and an important vegetable crops grown in India. Productivity of onion is affected by many biotic and abiotic stresses. Among the biotic stresses, diseases play an important role and among them, purple blotch caused by *Alternaria porri* is one of the most destructive diseases. The study was conducted to check the efficacy of different fungicides and bio-agents under field condition. The results revealed that among the chemicals difenoconazole 25 EC (Score) @ 0.1 % was found effective in reducing the disease with a per cent disease reduction of 62.23 over control. Among the bio-agents tested *Trichoderma harzianum* was found effective with the per cent disease reduction over control of 54.47 followed by treatment of combination of *Trichoderma harzianum* and *Pseudomonas flourescens* (41.91).

Management of Alternaria blight of sunflower through bio-agent and fungicides

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Biological control of plant pathogens through antagonistic microorganisms is a potential, ecofriendly and alternative to the chemical management of diseases. *Alternaria* blight is an important destructive disease of sunflower commonly managed using chemicals. Hence an attempt was made to manage *Alternaria* blight through bio agents and fungicides. All the treatments tried were significantly effective in reducing the severity of *Alternaria* leaf spot. At 50 per cent grain filling stage, the severity of *Alternaria* leaf spot varied from 25.00 to 76.25 per cent. In T₃ (Seed treatment with *Pseudomonas fluroscence* @ 10g/kg seed followed by spray of propiconazole @ 0.1% at 45 and *P. fluroscence* @ 1.0% at 60 days after sowing) the severity of *Alternaria* leaf spot was lowest (25.00%). The next best treatment was T₁- seed treatment with *Pseudomonas fluroscence* @ 10g/kg seed followed by 2 sprays of *P.fluroscence* @ 1.0% at 45 and 60 days after sowing with disease severity of 33.5 per cent. The disease severity was 76.25 per cent in control. The yield was significantly superior over control in all the treatments, T₂ (seed priming (carbendazim 2 g/kg seeds + thiomethoxam @ 0.04 %) + spray of propiconazole @ 0.1% +thiomethoxam @ 0.04% as soon as disease appears and 15 days later), T₃ (Seed treatment with *Pseudomonas fluroscence* @ 10g/kg seed followed by spray of propiconazole @ 0.1% at 45 and *P. fluroscence* @1.0% at 60 days after sowing) and T₄ (seed priming (carbendazim 2 g/kg seeds + thiomethoxam @0.04 %) + spray of propiconazole @ 0.1% + azadarictin @ 1.5 ml/l as soon as disease appears and 15 days later) were on par in inducing systemic resistance against *Alternaria* leaf blight.

Evaluation of components for integrated management of important diseases of sunflower

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Sunflower (*Helianthus annuus* L.) is an important oil seed crop and when introduced during early 1970s was free from diseases. The popularity of the crop among farmers resulted in larger area under the crop many diseases have co-evolved with sunflower. *Alternaria* blight emerged as a major threat in the cultivation during late 1980's. During 1997 sunflower necrosis disease caused by tobacco streak virus belonging to Ilar virus group was reported. Severe foliar (80%) infections by powdery mildew were observed during 2006 at Challakere, Chitradurga district in Karnataka. An average of 25-40 per cent yield loss was reported due to different diseases in sunflower (Shankergoud *et al.*, 2006). In the present investigation, field evaluation of various components for integrated management of important diseases of sunflower was conducted for three consecutive years 2013-14 to 2015-16. In the pooled data all the treatments reduced the disease significantly compared to the unsprayed control. T₂ (seed treatment with *Pseudomonas fluorescens* @ 10 g/kg seed followed by spray of hexaconazole @ 0.1% at 45 and *P. fluorescens* @1.0% at 60 days after sowing) recorded the least disease severity of *Alternaria* leaf spot (19.9%), which was significantly superior over all the other treatments. T₁ and T₃ with disease severity of 26.00 and 28.33 per cent respectively were on par with each other. The necrosis virus disease was least in T₁ (seed biopriming with *Trichoderma viridae* @ 10 g/kg seed +spray of propiconazole @ 0.1% +thiomethoxam @ 0.04% as soon as disease appears and 15 days later) treated plots which was on par with T₂. In the pooled data highest seed yield was recorded in T₁ which was significantly superior over other treatments. The economic analysis of cost benefit ratio calculated showed that highest income was obtained in T₁ (Rs 14,761) and the incremental cost benefit ratio was also highest in T₁. Hence T₁ (seed biopriming with *Trichoderma viridae* @ 10 g/kg seed +spray of propiconazole @ 0.1% +thiomethoxam @ 0.04% as soon as disease appears and 15 days later) is effective in the integrated disease management of important diseases in sunflower.

Compatibility of *Trichoderma viride* and *Trichoderma harzianum* with fungicides, insecticides and herbicides against soil borne diseases of tomato and cabbage

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A study was undertaken to evaluate the compatibility of commonly used fungicides, insecticides and herbicides at recommended dosages with *T. viride* and *T. harzianum* being used as a biocontrol agents against soil borne diseases of tomato and cabbage under *in vitro* and *in vivo* conditions. Results indicated that among systemic fungicides, azoxystrobin was found highly compatible with *T. viride* and *T. harzianum* at all the three tested concentrations (0.05, 0.10 and 0.15 %) followed by metalaxyl. With respect to non-systemic fungicides, mancozeb recorded least inhibitory effect on *Trichoderma* sp. Among systemic insecticides, fipronil (@ 0.15, 0.2 and 0.25 %) was found highly compatible with *T. viride* and *T. harzianum* followed by imidachloprid. With respect to non-systemic insecticides, maximum inhibition of *Trichoderma* sp. was observed with the quinalphos followed by chloropyriphos at 0.15, 0.20, 0.25 per cent concentrations. Among the herbicides, glyphosate was found to be highly compatible (@ 0.05, 0.1 & 0.15 % concentrations). Further compatible combinations were evaluated to know the survival of population of *Trichoderma* in soil media cropped with tomato and cabbage and compatible combinations at their recommended dosage can be recommended for integrated management of soil borne pathogens of these crops.

Integrated management of *Fusarium* and *Sclerotium* in blackpepper

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Black pepper nursery is inflicted by an array of soil borne plant pathogens of which *Fusarium* and *Sclerotium* are the most devastating causing 100% crop loss. A study was conducted at Pepper Research Station, Panniyur to assay the effect of chemicals and biocontrol agents (*Trichoderma viride* and *Pseudomonas fluorescens*) against the above pathogens. The pathogens were isolated from the infected plants in the pepper nursery and its pathogenicity was proved. The morphological characters were studied and the pathogens were identified as *Fusarium solani* and *Sclerotium rolfsii*. *In vitro* inhibition of the pathogens against the fungicides was tested by poisoned food technique. The fungicides tested were contact (copper oxy chloride, bordeaux mixture, copper hydroxide), systemic fungicides (carbendazim, hexaconazole, propiconazole) and combination fungicide (carbendazim and mancozeb) at recommended, higher and lower doses. Among the different fungicides assayed, effective ones for the management of *Fusarium* and *Sclerotium* were Bordeaux mixture, hexaconazole, propiconazole and carbendazim+mancozeb. The above fungicides at recommended and higher doses were effective in reducing the mycelial growth of the pathogen. Copper oxy chloride and copper hydroxide were ineffective in managing the pathogens. The systemic fungicide carbendazim had a negative effect on the pathogens and has promoted growth of bacteria. The biocontrol agents tested had antagonistic activity against *Fusarium* and *Sclerotium*. The mycelial growth of the tested pathogens was effectively suppressed by the overgrowth of *Trichoderma*. *Pseudomonas fluorescens* also inhibited the mycelial growth of the pathogens by antibiosis.

Management of bacterial leaf blight of rice caused by *Xanthomonas oryzae* pv. *oryzae* under field condition

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Bacterial leaf blight (BLB) is considered as a major threat to paddy production because of its wide spread, distribution and its destructiveness under favourable conditions. The disease is caused by *Xanthomonas oryzae* pv. *oryzae* is one of the most destructive diseases in irrigated and rain fed environment in Asia and cause considerable loss. Chemicals are the important components for mitigating the plant diseases. Hence, commercially available antibiotics and other antibacterial chemicals were evaluated against the disease. The biocontrol agents are also equally important in disease management. Thus, a field trial was conducted during *Kharif* 2016 at AHRS, Bavikere to know the efficacy of different commercially available antibacterial chemicals and bio-agents against the bacterial leaf blight of rice. Results indicated that, streptomycin @ 0.5g/l+ copper oxychloride @ 2.5g/l treated plots showed the lowest per cent disease incidence of 22.33 per cent followed by bacterinashak @ 0.5g/l, agrimycin 100 @ 0.2g/l and kasugamycin @ 2 ml/l and the highest disease severity was recorded in control (55.53%). Highest grain yield of 56.49 q/ha was recorded in streptomycin + copper oxy chloride, which was significantly superior over all other treatments, followed by bacterinashak (54.24 q/ha), kasugamycin (50.13 q/ha) and agrimycin 100 (49.38 q/ha). The least grain yield was obtained in *Bacillus subtilis* (41.33 q/ha).

Management of peanut bud necrosis disease (PBND) through integration of different strategies

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Two season field experiment was conducted during summer 2014 and 2015 on management of PBND through integration of different strategies. Three different modules were framed and compared with farmers practice and control plots. The PBND incidence was not noticed even though the thrips population was good enough when the crop was 20 days old. However, 4 to 5 percent PBND was noticed when crop was 27 days old in farmers practice plot and control plot respectively during 2014. Similarly, 3 to 4 percent was noticed during summer 2015. Whereas, no incidence was noticed in the plots where modules were imposed. There after the incidence of PBND was gradually increased in all the treatments with differential incidence. Among the different modules, module II comprising of border crop with bajra (4 rows)+ seed treatment with Gaucho 480 Fs @1ml / Kg seed + foliar sprays using thiodiazoxon 480 Fs @ 150 ml / ha at 20-25 DAS followed by fipronil 5SC @ 1ml/lit @ 40 DAS and acetamiprid 20 SP @ 100 g/ha at 60 DAS was found effective in reducing PBND with the maximum disease incidence of 4 and 7 percent only during 2014 and 2015 respectively with 22 and 24 number of thrips population in 10 terminal buds of the groundnut during a week before harvest as compared to control plot where the disease incidence of 14-18 percent with the average number of thrips population was 65-69 respectively during 2014 and 2015. The module also supported higher yield 10.63 q/ha in 2014 and 11.56 q/ha in 2015 as against to control plot. (9.40 q/ha).

Integrated management of powdery mildew of sunflower (*Golovinomyces cichoracearum* (DC.) V. P. Heluta)

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Sunflower (*Helianthus annuus* L.) is an important oil seed crop belonging to Asteraceae family. Powdery mildew of sunflower incited by *Golovinomyces cichoracearum* (DC.) V. P. Heluta is one of the most important diseases causing economic yield loss in recent years. Use of chemicals has become more popular in recent times because of their quick results, especially in absence of resistant varieties. Among the 10 treatments formulated and evaluated first spray of difencozole (0.05%) followed by *Pseudomonas fluorescens* spray (0.5%) and treatment of first spray of myclobutanil (0.05%) followed by *P. fluorescens* spray (0.5%) were found to be effective in managing the powdery mildew of sunflower and increased the yield by 8.54 and 8.51 q/ha respectively. In terms of B:C ratio first spray of myclobutanil followed by *P. fluorescens* spray (1: 2.00) and first spray of difencozole followed by *P. fluorescens* spray (1: 1.93) were found superior. Whereas, untreated control recorded the maximum PDI of 56.25 with minimum yield 6.37 q/ha and least B: C ratio of 1: 1.24.

***In vitro* evaluation of botanicals and bioagents against powdery mildew disease caused by *Golovinomyces cichoracearum* DC. H. P. Heluta in sunflower**

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Powdery mildew caused by *Golovinomyces cichoracearum* (DC.) H. P. Heluta is one of the major constraints in the production of sunflower. The present investigation was aimed to study the antifungal activity of seven botanicals and four bioagents at different concentrations with respect to inhibition of conidial germination of *G. cichoracearum*. The result clearly indicated that among the botanicals, turmeric showed maximum inhibition of conidial germination (81.37%) followed by garlic (78.26%) at 10 per cent concentration. Irrespective of concentration tested, turmeric (70.64%) inhibited conidial germination to greater extent followed by garlic (69.35%) and least inhibition of conidial germination was observed in tulsi leaf extract (43.22%). However, in bioagents maximum conidial germination inhibition was observed in *Pseudomonas fluorescens* (73.43%) followed by *Trichoderma viride* (61.87%) at 0.5 per cent concentration. Irrespective of bioagent concentrations, *P. fluorescens* (63.87%) significantly superior in inhibiting conidial germination over rest of the bioagents evaluated followed by *T. viride* (54.60%) and least inhibition of conidial germination was observed in *Bacillus subtilis* (48.26 %).

Integrated management of chilli powdery mildew incited by *Leveillulataurica* (Lev.) Arn.

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Powdery mildew incited by *Leveillula taurica* (Lev.) Arn. is a devastating disease of chilli. In the present investigation, management of powdery mildew disease was undertaken during 2015-16 by the application of fungicides, bioagents and botanicals under field conditions. Among the twelve treatments, myclobutanil (0.1 %) spray was found most effective in reducing the disease severity (PDI 17.37) followed by triadimefon (PDI 20.70) and hexaconazole (PDI 23.75) compared to control (PDI 88.24) respectively. The bioagents, *Pseudomonas fluorescens* (PDI 61.14) and *Trichoderma harzianum* (PDI 63.79) and the plant extracts viz., *Azardirecta indica* (PDI 62.56) and *Allium sativa* L. (PDI 63.54) were found less effective in reducing the disease severity as compared to fungicidal treatments respectively. Further, myclobutanil and triadimefon recorded higher dry chilli yield of 12.72 and 12.27 q/ha. The highest cost: benefit ratio was obtained in myclobutanil (1:2.43) sprayed plots followed by triadimefon (1:2.39) respectively. In the present study, the fungicide myclobutanil and triadimefon were found superior in reducing the chilli powdery mildew disease severity which remain on par with each other and thus helped for getting highest dry chilli fruit yield and B:C ratio.

Efficacy of fungicides and bioagents against *Colletotrichum gloeosporioides* causing anthracnose of mango (*Mangifera indica* L.)

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Mango (*Mangifera indica* L.) commonly called as “King of fruits” is the most important fruit crop in India. Among the various diseases, anthracnose, caused by *Colletotrichum gloeosporioides* Penz and Sacc. is the major constraint on extension of export of mango. Therefore efforts were made to screen the different systemic and combination of six fungicides, *in vitro*. Among systemic fungicides, propiconazole 25 per cent EC was successful in completely (100 %) inhibiting the growth of *C. gloeosporioides* at all four concentrations (0.025, 0.05, 0.1 and 0.15 %). thiophanate methyl 70 per cent WP and tebuconazole 25 per cent EC gave 100 per cent mycelial inhibition at three (0.05, 0.10 and 0.15 %) concentrations and combination of fungicides carbendazim 12 % WP + mancozeb 63 % WP was found the most effective and gave cent per cent growth inhibition at all four concentrations. Among the biocontrol agents, *Trichoderma viride* (Tv-2) and *Trichoderma viride* (Tv-1) gave maximum inhibition of mycelial growth of 78.22 % and 75.92 % of *C. gloeosporioides* respectively.

Integrated management of turcicum leaf blight of maize

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Maize is an important food and feed crop which ranks third after wheat and rice in India and the world. Because of its expanded use in the agro-industries it is recognized as a leading commercial cereal crop of great agro-economic value. Maize is cultivated under diverse environmental conditions. As the maize cultivation reaches its boom in terms of acreage, adoption of modern crop production practices like, using chemical fertilizers and chemical pesticides led the maize crop vulnerable to pests and diseases. Among the foliar diseases affecting maize, *Turcicum* leaf blight is of worldwide importance causing severe yield losses. So an integrated approach for the management of *Turcicum* leaf blight using different botanicals, bioagents and chemicals alone and in combination was carried out under field conditions in two seasons. Among the treatments tested, least per cent disease index was observed in foliar application of tebuconazole 50% + trifloxystrobin 25% @ 2 g/l treated plots with 49.67 which was on par with foliar application of propiconazole @ 0.5 ml/l (51.33), seed treatment with *Trichoderma harzianum* @ 4 g/kg + foliar spray of mancozeb @ 2 g/l + foliar application of neem seed kernel extract @ 5 ml/l (51.67) and foliar application of tebuconazole 50% + trifloxystrobin 25% @ 0.5 g/l (54.00). Whereas, maximum PDI was noticed in seed treatment @ 5 ml/l + foliar application of neem seed kernel extract @ 5 ml/l (65.67) and seed treatment with *Trichoderma harzianum* @ 4 g/kg + foliar spray of tebuconazole 50% + trifloxystrobin 25% @ 1 g/l + foliar application of neem seed kernel extract @ 5 ml/l (65.67) treated plots.

Nematode problems in protected cultivation and management

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Polyhouse farming or protected cultivation is an alternative new technique of cultivation in horticulture gaining foothold in rural India. It reduces dependency on rainfall, makes maximum use of land and other resources to produce more. This farming can help the farmer generate income round the year growing multiple crops apart from providing a better income. The polyhouse is actually a 'disease factory'. The crops under such cultivation are prone to several pathogens including nematodes, which could reduce the quality and quantity of produce. The ideal and stable environment with warm, humid and abundant food under poly house provides an excellent platform for the development of nematodes often more than field conditions. Major vegetable and ornamental crops grown under protected cultivation are seriously affected by root-knot nematode (*Meloidogyne* spp.), lesion nematode (*Pratylenchus* spp.,) and spiral nematode (*Helicotylenchus* spp.,), among others. Root-knot nematodes are more frequently associated with polyhouse crops. Plants growing in nematode-infested soils usually are unthrifty, stunted, yellowish, and have galled and decayed roots. Nematode infested plant roots are more susceptible to other diseases caused by fungi and bacteria, which leads to complex diseases and tend to stop producing early. In most cases, problems arise from contaminated soil or soil mixture used as a component of the growing medium, monocropping and infested planting materials. Nematode management must be considered primarily as exclusion or avoidance. Once nematodes are introduced it is difficult to manage them. Major strategies include drenching the soil with 0.5 per cent formalin at 100 ml/kg soil followed by covering with polythene tarps for two weeks before sowing/ planting ; adding well decomposed farm yard manure at rate of 20 tons per hectare to enrich soil; incorporating neem cake at 250 kg/ha soil two weeks before sowing/planting; applying *Purpureocillium lilacinum* / *Pseudomonas fluorescens* @ 2.5 kg/ha mixed with 50 kg farmyard manure ten days before sowing/ planting; use of nematicides like carbofuran 3G at rate of 1 kg./ha.

Effect of Phasfik -8 Potassium phosphanate for the management of foot rot (*Phytophthora capsici* Leon) disease in black pepper

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Black pepper (*Piper nigrum* L.) the king of spices is a traditional, historic spice crop which has been under cultivation since ancient times in India. It belongs to family Piperaceae, originated in evergreen forest of Western Ghats. This crop is known to be affected by many diseases of which foot rot caused by *P. capsici* is a serious malady, causing huge loss and is the major constraint in its cultivation particularly under areca based mixed cropping system. A field experiment on management of foot rot of black pepper was carried out by using fungitoxicants with two spray in a season during first week of June and third week of July and observation were recorded at 45 days after spray in Sirsi taluka of Uttara Kannada district of Karnataka during 2013-14. Mono and di potassium salts of phosphorous acid -32% + ionic copper 8% (Phasfik-8) as foliar spray and soil drenching (3l /vine) at 6 ml/l of water during first week of June and third week of July recorded statistically significant reduction in the disease with respect to leaf infection (18.52 and 11.11 PDI), leaf yellowing (14.81 and 9.26 PDI), leaf fall (7.41 and 5.56 PDI) and least death of vines (11.11 PDI) resulting in highest berry yield (1097kg/ha), which was statistically on par with potassium phosphonate (Akomin) at 6 ml/l and Phasfik -8 at 4.5 ml/l. However, soil application with antagonistic *Trichoderma viride* @ 50 g/vine and foliar spray with *Pseudomonas fluorescens* @ 1% during first week of June and third week of July has not shown any significant reduction in disease with respect to leaf infection (25.93 and 20.37 PDI), leaf yellowing (22.22 and 14.81 PDI), leaf fall (16.67 and 11.11 PDI) and death of vines (22.22 PDI) resulting in significantly lower berry yield (807kg/ha). There was maximum disease incidence was observed in unprotected vines with a lowest berry yield (107kg/ha).

Exploring the role of WRKY1 in wild relative of tomato against *Alternaria solani*

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Wild relatives of crop plants harbour many potential plant defence genes. *Solanum arcanum* Peralta is a wild relative of *S. lycopersicum* L. (Tomato) showing robust resistance against plant pathogens. Current high yielding cultivated tomato varieties are vulnerable to early blight (EB) caused by *Alternaria solani* leading to 32- 79% yield loss in tropical and subtropical countries. As transcription factors including WRKY plays a major role in regulating host defence, aim of present research was to identify and functionally characterize pathogen induced WRKY genes from tomato. We identified eight WRKY genes which were induced either early or late stage of infection. Further, we analysed WRKY1, as a potential candidate gene during EB defense. EMSA confirmed binding of recombinant WRKY1 protein with W boxes in native promoters of key cell wall modification element (*XTH5*) and *MYB2*. Transgenic tomato plants over expressing WRKY1 showed elevated levels of *XTH5* and *MYB2* genes with significant reduction in EB disease symptoms compared to non-transgenic plants. These two targets of WRKY1 could have resulted in physical barrier formation by cell wall modification and transcriptional regulation of defence genes. Thus, present study indicated the potential role of WRKY1 in EB resistance for the first time and could be useful in designing future strategies to improve crop protection against EB.

Integrated management of sunflower leaf curl disease caused by begomovirus transmitted by whitefly (*Bemisia tabaci*)

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Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops grown in India. In recent years, the crop suffers from sunflower leaf curl disease (SuLCD) with substantial losses in yields. SuLCD caused by tomato leaf curl Karnataka virus (begomovirus) and transmitted by whitefly (*B. tabaci*) is an economically important disease of sunflower and cause considerable yield loss in recent years. The study on the management of SuLCD using insecticides, leaf extracts and bioagents revealed that seed treatment with imidachloprid @ 5 g/kg along with two sprays of imidachloprid @ 0.5 ml/l or triazophos @ 1.5 ml/l were found very effective in controlling the disease and vector population with increased yield and benefit cost ratio. Seed treatment followed by two sprays of imidachloprid or triazophos at 30 and 45 DAS recorded significantly lower SuLCD incidence (34.73% and 38.33% respectively) with highest yield (13.20 q/ha and 12.67q/ha respectively) and BCR (2.15 and 2.14 respectively). Hence, SuLCD can be managed very effectively by seed treatment with imidachloprid along with two sprays of imidachloprid or triazophos at 30 and 45 DAS.

Occurrence, diagnostics, pathogen diversity and management of false smut of rice caused by *Ustilaginoidia virens*

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False smut called as “Laxmi disease” was a minor disease during earlier days and now it is becoming one of the important diseases of rice in recent years in TBP and UKP areas of north Karnataka. The survey indicated that the false smut incidence was more in transplanted system than direct seeded rice. Potato sucrose agar medium supported maximum radial growth followed by XBZ agar and potato dextrose agar. Variability was observed among the 15 isolates with regard to mycelial characters (colour and branching type), colony characters (growth and morphology) and chlamydospore character (colour and shape). In all the isolates of mycelial colour was predominantly white except in the few isolates which showed white to light pink colour and branching type was acute in all the isolates. The chlamydospore shape varied among the isolates and was globular, round irregular and ovoid. The size of the chlamydospore ranged from 5.45 (Uv13) to Uv6 (7.10 µm). The DNA of fifteen isolates of *U. virens* belonging to different geographic regions was successfully amplified with general ITS1 and ITS4 primers set and specific UVR1 and UVR4 primers set. The size of amplified DNA ranged from 500 to 620 bp in general primers and 280 to 320 bp in specific primers. BLAST results revealed that all the isolates belonged to the *U. virens*. Phylogenetic analysis of fifteen *U. virens* isolates was constructed using UPGMA-NJ online software representing north eastern Karnataka. The dendrogram clearly showed two major clusters A and B. At 75 per cent similarity coefficient, isolates clearly clustered into 5 clusters. Cluster-I include 2 isolates, Uv 6 from R.H. Camp of Sindhanur taluk and Uv 10 from Kampli of Hospet taluk. Cluster-II contained 6 isolates, three from Raichur district (Uv 1 from Kalmala, Uv 3 from Sirawara and Uv 5 from Javalagera). Cluster-III included five isolates (Uv 4 from Neer Manvi of Manvi taluk, Uv 12 from Devapur, Uv 13 from Devi Camp, Uv 14 from ARS Gangavathi and Uv 15 from Hitnal) and finally Cluster-IV had isolate Uv 9 from Vijayanagara Camp, and Uv 2 from Nelhal of Raichur taluk. Carbendazim, hexaconazole, propiconazole, penconazole and tebuconazole among systemic fungicides, new molecule (trifloxystrobin 25 % + tebuconazole 50%) WP among combi fungicides were highly effective in inhibiting the mycelial growth of the fungus under *in vitro*. The data over two years (2015-16) under field condition revealed that two sprays of trifloxystrobin 25 % + tebuconazole 50% EC (0.4%) at 60 and 75 DAT was highly effective in the management of disease with significantly lesser disease severity (15.01%) and highest yield (54.66 /ha) with higher B:C ratio (2.10).

Field evaluation of fungicides, plant extracts and bio control agents against powdery mildew of mulberry caused by *Phyllactinia corylea*

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Mulberry powdery mildew caused by *Phyllactinia corylea* is one of the important catastrophic diseases and an obligate parasite. The efficacy of fungicides, plant extracts and bio-control agents against powdery mildew of mulberry was assessed under field conditions. Irrespective of the fungicide (0.1, 0.2 and 0.3 per cent) concentration the tebuconazole 50% +trifloxystrobin 25% WG (74.76%) and hexaconazole 5% EC (66.28%), were found to be more effective in reducing the disease over control. Regardless of phytoextract (5, 10 and 15 per cent) concentrations, *Zingiber officinale* reduced the disease to 60.31 per cent and *Lantana camara* to 59.04 per cent disease over control and is considered as best for managing powdery mildew disease in mulberry. Despite the filtrate (5, 10 and 15 per cent) concentrations of bio-control agents used, *Trichoderma harzianum* reduced the disease to 51.56 per cent and *Pseudomonas fluorescens* to 51.09 per cent over control and were shown to be potent in fading the disease.

Effect of mulberry intercropping on disease management

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Mulberry is a perennial, evergreen, luxuriant crop cultivated in all most all types of soils. Mulberry (*Morus* sp.) leaves form the sole food source of silkworm (*Bombyx mori* L). Success of silkworm crop depends upon the quality and quantity of mulberry leaves. Diseases are one of the limiting factors for successful mulberry cultivation. The crop is prone to depredation of diverse pathogens, due to its fast growth and green foliage throughout the year. This favor the survival, multiplication and inoculum built up of certain foliar and soil borne pathogens causing different diseases. Many fungal and bacterial diseases are seen in mulberry, which affect the quality of mulberry leaves. Hence, integrated disease management helps in keeping the mulberry leaves free from diseases. One among the disease management is through intercropping in mulberry. Due to intercropping of solanaceous vegetables in mulberry reduced the disease incidence of powdery mildew (*Phyllactinia corylea*) and fungal leaf spot (*Cercospora moricola*). This reduced incidence may be due to the utilization of space between the mulberry rows, which creates the high temperature and other unfavorable conditions that stops the multiplication of pathogens. As well intercropping helps in removal of alternate hosts which are congenial for development of pathogens. Hence, intercropping is one of the integrated methods along with the other methods in management of mulberry diseases in order to obtain successful and profitable cocoon crop.

Study on efficacy of different botanicals on management of *Alternaria solani* causing early blight of tomato under *in vitro* conditions

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Alternaria rot has been considered as the most common disease of tomato and other solanaceous crops and causes heavy losses in quality of the fruits, thus rendering large quantity of tomato fruits unfit for consumption. Due to increasing awareness of environmental pollution by way of continuous use of chemical pesticides and their residual toxicity on crops like efforts are being made to use some eco-friendly substitutes like plant extracts. In view of their non phytotoxicity and systemic actions, they have gained the attention. Several plant extracts known to possess antifungal activities are being exploited to manage fungal plant disease. In an approach towards the development of eco-friendly management, *in vitro* antifungal assay was conducted in the Department of Agricultural Microbiology, UAS, GKVK, Bengaluru. The efficacy of 10 plant extracts (*Pongamia pinnata*, *Azadirachta indica*, *Zingiber officinalis*, *Allium sativum*, *Melia dubia*, *Nerium odorata*, *Eucalyptus globules*, *Lantana camera*, *Eupatorium* and *Psidium guajava* L.) were evaluated against *Alternaria solani* under *in vitro* condition for radial growth of mycelium at three different concentration (10, 20 and 30%) by using piosion food technique. Highest inhibition activity was found in *Azadirachta indica* (63.58%) followed by *Pongamia pinnata* (57.48%), *Allium sativum* (54.33%), *Zingiber officinalis* (48.02%) and *Psidium guajava* L. (46.02%) at 30% concentration. From the above study, it is observed that *Azadirachta indica* extract is more effective against *Alternaria solani*. The present study suggests that, the plant based extracts could be an alternative strategy to synthetic fungicides and also aid in sustainable and chemical residue free food production.

Evaluation of plant based extracts against plant pathogen *Fusarium oxysporum f. sp. lycopersici* under *in vitro* condition

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Fusarium oxysporum f. sp. lycopersici is an important plant pathogen that causes wilt in tomato crop. Management through chemical fungicides cause serious environmental problems and are toxic to non-target organisms as well. Plant metabolites and plant based extracts appear to be one of the better alternative strategies as they are known to have minimal environmental impact and are non-hazardous to consumers in contrast to synthetic pesticides. In an approach towards the development of eco-friendly management, *in vitro* antifungal assay was conducted in the Department of Agricultural Microbiology, UAS, GKVK, Bengaluru. Ten different botanical extracts (*Duranta*, *Allium cepa*, *Capsicum annuum*, *Carica papaya*, *Nerium oleander*, *Zingiber officinarum*, *Allium sativa*, *Vinca rosea*, *Lantana camara* and *Azadirachta indica*) at three different concentrations (10%, 20%, and 30%) were evaluated against *F. oxysporum f. sp. lycopersici* by using poison food technique. Out of ten, five botanical extracts were proved to be potential in inhibiting the growth of the *F. oxysporum f. sp. lycopersici* at 30% concentration viz., *Allium cepa* (71%), *Allium sativum* (55.26%), *Capsicum annuum* (61.68%) *Azadirachta indica* (71.05 %), *Lantana camara* (48.42%). This study suggests that the botanical extracts could be an alternative in developing a potent plant based fungicides which can be used in organic farming for the management of *F. oxysporum f. sp. lycopersici* in an ecofriendly manner.

In vitro* evaluation of botanicals, bio agents and fungicides against stem bleeding of coconut caused by *Thielaviopsis paradoxa

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Stem bleeding disease of coconut caused by *Thielaviopsis paradoxa* (de Seynes) von Hohnel is one of the important soil borne diseases of coconut and is widely prevalent in different coconut growing areas of the country and it is the one of the limiting factor for production of coconut in Karnataka. Bio-efficacy of seven isolates namely *Trichoderma viridae* (GKVK), *Trichoderma harzianum* (GKVK), *Trichoderma asperillum* (GKVK), *Trichoderma harzianum* (HRS), *Trichoderma harzianum* (NBAIL), *Trichoderma harzianum* (KRN) and *Trichoderma harzianum* (MYS) and ten systemic and three contact fungicides were evaluated under *in-vitro* conditions against *Thielaviopsis paradoxa*. Among the seven antagonists tested, all the antagonists significantly reduced the growth of *Thielaviopsis paradoxa* by recording mycelial inhibition ranging from 61.78 to 76.00 per cent. Among the antagonists tested *Trichoderma asperillum* (GKVK) was found superior over all other bio-agents by recording maximum inhibition of 76.00 per cent followed by *Trichoderma viridae* (GKVK) which has recorded 74.89 per cent. Least inhibition of 61.78 per cent was recorded in *Trichoderma harzianum* (KRN). Among the twelve fungicides evaluated carbendazim 50%WP @ 0.1%, difenoconazole 25%EC @ 0.1%, propiconazole 25%EC @ 0.1%, tebuconazole 25.9%EC @ 0.15% and thiophanate methyl 70%WP @ 0.2% has recorded cent percent inhibition compared to other fungicides and showed significant difference among the treatments in inhibiting the growth of the pathogen. Azoxystrobin 23%SC @ 0.1% which recorded least inhibition of 1.56% followed by 1.82% in pencycuron 22.9%SC @ 0.15% on 9 DAI. The present study indicated that biocontrol agents have shown significant inhibition of *Thielaviopsis paradoxa* and was comparable with fungicides.

Influence of various treatments on growth and yield parameters of black pepper infested with *R. similis* and *P. capsici* under field conditions

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Influence of bioagents, organic amendments and chemicals were studied for the management of *R. similis* and *P. capsici* on black pepper and observations on plant growth parameters like number of runner shoots, number of spikes, spike length, spike weight and dry weight of berry per vine was recorded during 2015-16. Significant differences between the treatments was observed during the study and maximum number of runner shoots, number of spikes, spike length, spike weight and dry berry weight per vine were recorded in combination treatments as compared to individual treatments and untreated control. The vines treated with Bordeaux mixture (1%) + *T. harzianum* (50 g) had recorded highest number of runner shoots (38.66 cm), number of spikes (389.33), spike length (24.66 cm), spike weight (4141.33 g) and dry weight of berries (3.68 kg per vine) followed by Bordeaux mixture (1%)+ *P. lilacinum* (50 g) with 33.33 cm, 364.00, 21.33 cm, 4013 g per vine and 3.37 kg/vine, number of runner shoots, number of spikes, spike length, spike weight and dry berry weight respectively. However lowest performance was recorded in untreated control (6.00, 68.66, 4.66 cm, 950.33 g and 0.50 kg per vine) respectively.

Management of collar rot of groundnut caused by *Aspergillus niger* van Teighem under *in vitro* and *in vivo* conditions

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Groundnut (*Arachis hypogaea* L.) is a very important legume and oilseed crop grown in India. Collar rot is one of the most important diseases of groundnut in Karnataka caused by *Aspergillus niger* van Teighem. Pathogen is a well-known polyphagous, ubiquitous, non-target and the most destructive soil and seed inhabiting fungus reported so far. To manage this disease twenty different fungicides, thirteen bioagents and ten botanicals were evaluated in lab condition and different fungicide treated seeds were evaluated in field conditions. Systemic fungicides viz., propiconazole, tebuconazole, flusilazole and combi-product fungicides viz., flusilazole 12.5% + carbendazim 25% SE recorded 100 per cent mycelial growth inhibition at all the concentrations. Among non systemic fungicides chlorothalonil showed maximum per cent inhibition of 64.63 at 3000 ppm concentration. *Bacillus subtilis* P-21, showed maximum mycelial inhibition of 84.81 per cent, among fungal bioagents evaluated maximum inhibition per cent of 66.48 was recorded by *Trichoderma harzianum*-16. Neem and garlic recorded maximum mycelial inhibition per cent of 45.18, 51.33, 63.66 and 51.66, 55.33, 60.00 at concentration of 5, 10 and 15 per cent respectively. Tebuconazole seed treatment recorded lowest disease incidence of 7 per cent with highest pod yield of 12.8 q/ha and haulm yield of 31.6 q/ha.

Seed mycoflora associated with chickpea (*Cicer arietinum* L.) with special reference to *Rhizoctonia bataticola* (taub.) Butler.

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The chickpea seed samples collected from different parts of northern Karnataka revealed the dominance of per cent total fungal count in variety JG -11. Among different seed health testing methods, water agar method was found to be good for detecting the seed borne infection of *R. bataticola* to an extent of 26.32 %. The pathogenic ability of seed borne infection of *Rhizoctonia bataticola* was proved in seed to plant transmission study. Component plating technique proved the seed borne nature of *Rhizoctonia bataticola*. Among eight seed dressing fungicides tested against *R.bataticola* by poisoned food technique and paper towel method, carbendazim was found most effective followed by carboxin + thiram at both 0.1 and 0.2 per cent concentration. Among the four bio-agents tested for their efficacy against *R. bataticola*, maximum inhibition of mycelial growth was noticed by *Trichoderma harzianum* (78.67 %) in dual culture technique. In paper towel method, seed treatment with *Trichoderma harzianum* at 1.2 per cent concentration showed least per cent seed infection with maximum per cent germination and vigour index. Among the seven treatments tested for effect of bioprimering on per cent germination, per cent infection and seedling vigour index on chickpea seeds, the treatment *P. fluorescens* @ 0.8 % + *T. harzianum* @ 0.8 % + vermiculite showed least percent seed infection and highest per cent seed germination and seedling vigour index.

Varietal assessment and management of chickpea wilt through fungicide and bio pesticides

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The chickpea is the most important *rabi* crops of North Karnataka. Different varieties viz., JG-11, JG-14 and Annigeri were evaluated to know the *Fusarium* wilt incidence in Kalaburgi during 2015-16 and 2016-17. The results showed that, incidence of wilt varied between the varieties from 4.0 to 17.5 percent. Among the varieties, least wilt incidence (4.0 %) was recorded in JG-11 followed by JG-14 (5.5 %) and higher incidence (17.5 %) was noticed in Annigeri. The experiments was undertaken to know the effect of fungicides and bio-agents on wilt and its pathogen in variety Annigeri. Among the fungicides tested *in vitro* against the wilt pathogen, only two chemicals viz., carbendazim and carbendazim + mancozeb in higher concentration proved to be the most effective as they inhibited (100 %) the fungus growth completely. Whereas, carboxin, captan, metalaxyl and thiophanate methyl were found to be next best in inhibiting the growth of the pathogen ranging from 83 to 90 per cent. In field conditions, maximum seed germination was observed in carbendazim seed treatment (91.0 %) with very less wilt incidence (7.1 %) along with higher grain yield (12.6 qt/ha). Maximum wilt incidence was noticed in metalaxyl seed treatment (32.21 %) with lower germination percentage (80.0 %) and yield (9.2 qt/ha). Among the bio-agents tested both *in vitro* and *in vivo*, *Trichoderma* was found to be best in field conditions resulted with lower incidence of wilt (6.7 %), higher seed germination (95.0 %) and yield (12.9 qt/ha).

Pulse magic with IPDM practice on yield enhancement of transplanted pigeon pea in kalaburagi district

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Kalaburagi is called as “Pulse bowl of Karnataka”. Pigeon pea productivity decreasing continuously due to various biotic and abiotic stresses which made its cultivation unreliable and uneconomical. The Krishi Vigyan Kendra, Kalaburagi conducted 30 demonstrations in farmers field at different villages of Kalaburagi district during 2014-15 to enhance the yield of transplanted pigeon pea (BSMR-763). There are two treatments consisting of T₁: Spray of Pulse magic (Pulse magic is a product developed by UAS Raichur, contains 10% of nitrogen, 40% of phosphorus, 3% of micronutrients and 20 ppm PGPR). Pulse magic @ 10 g + NAA @ 0.25 ml per liter of water sprayed twice, i.e., first spray at 50 per cent flowering stage and second spray at 15 days after first spray with two irrigation, nipping at 30 day after transplanting, INM, IWM, IPM and improved production technology followed as compared to T₂: Check - No spray of pulse magic and other all practices same as T₁. The results revealed that, the highest yield of 28.57 q/ha obtained in demonstration plot (T₁) when compared to check (T₂-25.14 q/ha) which was 13.64 per cent higher yield compared to check. The higher yield parameter were recorded viz., number of pods/plant (1365), seeds/pod (3.5), test weight (11.34 g), seed yield/plant (220 g) when compared to check (T₂: 1294, 3.2, 11.10g, 461.87g and 19.38g, respectively). The *Cercospora* leaf spot and flower drop was managed by spraying carbendazim @ 1 g + Pulse magic @ 10 g per litre.

Management of root-knot nematode (*Meloidogyne incognita*) in turmeric cv. Salem by using bioagents, botanicals and chemicals

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Turmeric is one of the important spice crops grown in India and used to flavour and colour to foodstuffs. It is an herbaceous perennial plant, native to tropical south-east Asia belonging to the family *Zingiberaceae*. The anti-oxidant attributes of this spice protect against the high energy free radical damage to organic cells. The root-knot nematode (*Meloidogyne* spp.) is one of the major problems, which causes galls/knots in the rhizomes and leads to considerable yield losses. A pot experiment was conducted to manage the root-knot nematode using bioagents, botanicals and chemicals. The maximum plant height (68.75 cm), fresh rhizome weight (308.25 g), dry rhizome weight (62.13 g), least number of galls (26.25) and lowest soil nematode population (201.75) was found in T₂- carbofuron 3G among the individual treatment and it was significantly superior over other individual treatments and control followed by T₃-*Trichoderma viride* and T₁ - neem cake. In combination treatments T6- neem cake + *Paecilomyces lilacinus* performed better with maximum plant height (72.00 cm), fresh rhizome weight (325.00 g), dry rhizome weight (65.00 g) and least number of galls (23.50) and lowest soil nematode population (153.25), which was on par with T5- neem cake + *Trichoderma viride* when compared to control. In general, all individual and combination treatments performed better and significantly superior over control.

Integrated management of rhizome rot of banana cv. grand naine (aaa)

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An experiment was conducted during 2012-13, 2013-14 and 2015 at K.R.C. College of Horticulture, Arabhavi, UHS, Bagalkot. There were eleven treatments, each treatment was replicated three times with a randomized block design. A susceptible cultivar Grand Naine was planted with a spacing of 1.8 x 1.8 m. Results revealed that, disease free suckers from disease free field + dipping in copper oxychloride @ 4g/lit + streptomycin @ 0.3g/lit for 45 min followed by drenching with copper oxychloride @ 3g/lit + streptomycin @ 0.3g/lit for three times at 30 days interval effectively controlled the rhizome rot disease (3.70%). The next best treatments were healthy suckers + drenching with streptomycin 1 liter per plant @ 500 ppm (15 days, 2nd month, 4th month after planting) + growing sunhemp in the interspaces till 6 months after planting (12.03%), healthy suckers + dipping in streptomycin for 30 min @ 500 ppm (13.89%), healthy suckers + soil application with 6g bleaching powder 5 times at monthly intervals up to 4 MAP (months after planting) + drenching with streptomycin 1 lit /plant (500ppm) at 1st MAP + *Trichoderma viride* (50g/plant at 2nd, 4th MAP) + growing sunhemp in the interspaces till MAP (20.37%) and healthy suckers + drenching with *Pseudomonas fluorescens* 1 lit/plant @ 50gm per liter of water 5 times at monthly interval + growing sunhemp in the interspaces till 6 months after planting (24.07%). The highest incidence (37.03%) was recorded in healthy suckers. With regards to yield in the year 2012-13 indicated that, the highest yield (78.95t/ha.) was recorded in the treatment of disease free suckers from disease free field + dipping in copper oxychloride @ 4g/lit + streptomycin @ 0.3g/lit for 45min followed by drenching with copper oxychloride @ 3g/lit + streptomycin @ 0.3g/lit for three times at 30 days interval. The next best treatments were healthy suckers + drenching with streptomycin 1 liter per plant @ 500 ppm (15 days, 2nd month, 4th month after planting) + growing sunhemp in the interspaces till 6 months after planting (71.49t/ha) and healthy suckers + dipping in streptomycin for 30 min. @ 500 ppm (68.11t/ha).

Bio-intensive management of thrips transmitted bud blight disease of tomato

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In the recent years, tomato is being grown extensively in Karnataka and it suffers from fungal, bacterial and viral diseases. Among the viral diseases, bud blight disease of tomato caused by *Peanut bud necrosis virus* (PBNV) transmitted by thrips is a serious problem in north eastern Karnataka. In order to find a solution to this problem a field experiment was conducted during *kharif* 2014 at MARS Raichur, with different chemical schedule which included new chemical molecules, bio agents and botanicals. Among the different chemical schedule, the best schedule was T5 (seedling dip with imidachloprid 17.8 SL at .03ml/l - *P. fluorescens* @ 5g/l - thiamethoxam 0.2 g/l - neem oil (1500 ppm) @ 5 ml/l at 15 days interval from planting), followed by T6 (seedling dip with imidachloprid 17.8 SL @ 0.03ml/l - *P. fluorescens* @ 5g/l - dinotefuron 20 SG @ 0.2 g/l - neem oil (1500 ppm) @ 5 ml/l at 15 days interval from planting) with the disease reduction of 50.00 per cent and 45.99 per cent respectively and a yield of 29.12 t/ha and 26.03t/ha respectively.

Mechanism of fungicide resistance in fungal plant pathogens

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Use of chemical fungicides has been one of the key strategies in plant disease management. Development of resistance to fungicides is a major concern. Fungicide Resistance is a stable, heritable trait that results in a reduction in sensitivity to a fungicide by an individual fungus. Practically, the labeled rates of a fungicide no longer provide commercially acceptable control of a disease. Till 1980s only fungicides like coppers, organo-mercuries and dithiocarbamates that act on multiple sites of biochemical inhibition in fungal cell were used. Multi-site target fungicides like mancozeb and chlorothalonil which are generally protectants pose low risk while single site target fungicides like benzimidazoles and strobilurins which are penetrants into plant system pose high risk. Similarly non-sporulating fungi like *Rhizoctonia* and *Sclerotium* pose low risk while powdery mildews and oomycetes pose high risk. Use of single site target fungicides for the management of powdery mildews like pathogens poses maximum risk. Both qualitative resistance resulting from single mutation in one gene and quantitative resistance (gradual reduction in control) due to mutation in several genes that interact have been reported. Similarly cross resistance and multiple resistance (resistance to different chemical classes developed independently) are the major concerns in the fungicide resistance management. Sterol biosynthesis inhibitors (SBIs) like triadimefon, tenarimol, mclobutanil, tebuconazole and triflumizole came into use between 1980 and 1990s for powdery mildews. They are single-site inhibitors of ergosterol synthesis. Resistance was reported for triadimefon in 1985 while for fenarimol and myclobutanil in 1995 and tebuconazole and triflumizole in 2005. Besides cross resistance among SBIs, multiple resistance has also been reported (i.e) resistance to strobilurins as well as SBIs. The strobilurins were first introduced in 1996 for grapes powdery mildews and later for other crops between 2001 and 2008. The mode of action is single site inhibition of energy production in mitochondria. Strobilurins resistance in grapes powdery mildews strains were detected in New York and Pennsylvania in 2002 in US and in Europe in 2006. Resistant downy mildew strains were detected in Europe in 2000 and in US 2005. Cross resistance among many strobilurins has been recorded. Resistance to benzimidazole fungicides in *Fusarium* species has been documented due to the mutation in benzimidazole binding domain in the beta tubulin proteins involved in cell division. The resistance to fungicides develops mainly by the survival and spread of initially rare mutants during treatment with fungicides. This fungicide resistance can be exhibited from a single gene mutation or multiple gene mutation. There are different molecular mechanisms for conferring resistance to fungicides. Resistances to fungicides are mainly due to loss of affinity to target site, decreased uptake or increased efflux of fungicide, detoxification or circumvention of block through an alternate pathway, absence of conversion to active compound and compensation, such as increased production of target enzyme. Fungicide resistance mechanisms to different fungicides such as the Demethylation Inhibitors, Strobilurins, Methyl Benzimidazole Carbamates and Succinate Dehydrogenase Inhibitors have been well recorded.



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