AICRP - BIOLOGICAL CONTROL

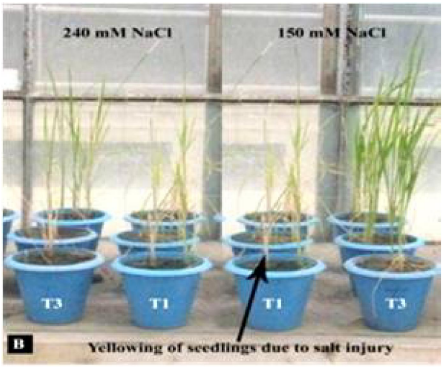
Objectives

- *In vitro* screening of available isolates of antagonists for their tolerance to abiotic stresses (drought, salinity) under *in vitro* conditions and their performance under rain-fed conditions.
- Evaluation of selected salinity tolerant isolates of *Trichoderma harzianum* on wheat, rice under saline conditions
- Field evaluation of promising *Trichoderma* isolates for the management of diseases and improved crop growth (rice, chickpea, lentil)
- Large scale field demonstrations of bio-control technologies in plains (rice, pea) and in hills of Uttarakhand (tomato, chilli, capsicum, brinjal and cabbage)
- Development of oil based formulations of *T. harzianum* for optimum shelf life
- Field evaluation of invert-emulsion formulation of *T. harzianum* for the management of foliar and soil borne disease of chickpea.
- Monitoring of emergence of newer pests and diseases of various crops in district Udham Singh and Nainital of Uttarakhand
- Development of cost-effective WP/EC based *Trichoderma* formulations and delivery system to increase their longevity and efficacy under field conditions.
- Identification, evaluation and exploitation of ISR activity of PGPR against spot blotch of wheat under controlled conditions
- Selection and promotion of plant growth promoting *Trichoderma* isolates for crop health under sustainable agriculture (crop; wheat, chickpea, rice)
- Evaluation of promising biological control agents against chilli anthracnose
- Promoting Bio-intensive IPM through a Common Minimum Programme amongst Buksa tribe in district U.S. Nagar in Uttarakhand state.
- Evaluation of Potential *Trichoderma, Pseudomonas* and *Bacillus* isolates for the management of pre & post emergence damping-off and improved growth in vegetable nursery beds (chilli, tomato and onion)

1. Significant Achievements:

- Isolated, identified and preserved more than 600 isolates of antagonistic microorganisms viz. *T. harzianum, T. hamatum, Hypocrea* sp., *Pseudomonas fluorescens, Bacillus* spp, *Beauveria bassiana, Verticillium* and *Metarrhizium* spp. as repository of bio-control antagonists in the bio-control lab, GBPUAT, Pantnagar. All of these *Trichoderma* isolates have been well characterized for their antagonistic potential (hyphal and sclerotial parasitization, antibiosis activity, etc.), plant growth promotion activity, induced systemic resistance, fungicide tolerance and abiotic stress *in-vitro, in-vivo* and in field.

- Of various *Trichoderma* isolates tested *in vitro* and *in-vivo*, 05 isolates were selected as salinity tolerant (Th-13, Th-14,Th-19,Th-33 and Th-55) in rice and 05 isolates as drought tolerant (Th-56, Th-62, Th-75,Th-82 and Th-89)in wheat. Salinity tolerant isolates viz. Th-14, Th-19 Th-13 and Th-33 and drought tolerant isolates viz. Th 56, Th 75, Th-69, Th 82 were found superior with respect to germination, shoot and root length, chlorophyll content, membrane stability index, phenol content, proline content and photosynthetic rate, chlorophyll fluorescence and stomatal conductance in treated wheat and rice plants under artificially salt stress, natural sodic soil and under water stress conditions.
- Expression of some key genes viz. *Pyrroline-5-carboxylate synthetase* (osmolyte production), SOD and APX (oxidative stress) and PAL (secondary metabolites production) were observed in treated plants through semi quantitative RT-PCR that might directly or indirectly be involved in salt stress tolerance.
- Two *Trichoderma* isolates viz. Th-14 & Th-19 were found good in managing *Fusarium* wilt of chickpea even in saline soils.
- Among 10 selected abiotic stress tolerant (drought and salinity) isolates, significantly maximum chitinase, glucanase and glucosidase activity was observed in Th-89; while significantly maximum cellulase activity was observed in Th-50, protease in Th-89, Th-14, Th-19, and Th-82.
- Nine different *Trichoderma* formulations were prepared using either *Trichoderma* culture filtrate or spore powder and tested for their shelf life kept at room temperature (25-35^{0}C) and at refrigerator temperature (4^{0}C). The initial CFU in different formulations just before storage ranged from 16-43x10^{7}cfu/g or ml. All the formulations retained a shelf life of 7 months (0.6-4.6 x10^{6}cfu/g or ml) at room temperature and 11 months (0.6-3.8 x10^7 cfu/g or ml) at refrigerator temperature during storage. Of various formulations, maximum viability after 7 months at room temperature and 11 months at refrigerator temperature was observed in paraffin oil 50% EC- spore based (4.6 & 3.8x10^6 cfu/ ml) followed by soybean oil 50% EC – spore based, (3.6 & 3.3x10^6 cfu/ ml), while minimum in gypsum 50% WP -filtrate based (0.6& 0.6x10^6 cfu/ g) respectively. These formulations were found significantly better in improving seedling and plant vigour and in reducing seed and plant mortality of chickpea in glasshouse. The results revealed that different formulations could be applied as per the needs viz. biological seed treatment, foliar spray and as paste for the eco-friendly plant disease management under IDM and organic farming.
- A total of 126 rhizobacteria were isolated from rhizosphere and rhizoplane, purified and identified as G$^-$ (74 no.) and G$^+$ (52 no.). Among these, only 07 isolates were found



Th 56 Th75 Th69 Th82 Th89 Check 7 days drought stress

CFU (x10^7)

WP, Oil and Paste based formulations

good in reducing disease severity of spot blotch of wheat (*Bipolaris sorokiniana*) in glasshouse, when applied as seed and soil treatment.

- A total of 72 *Trichoderma* isolates were isolated from rhizosphere and rhizoplane of rice, wheat, and chickpea for their growth promoting effects on the crops. Based on their growth promotion effects two isolates from each crop were selected and evaluated in their native crop and vice-versa. Glasshouse studies have revealed that native crop *Trichoderma* isolates were significantly more effective in increasing plant vigour in their respective crop. The study revealed that native crop antagonistic isolates could be exploited in a better way in managing soil borne plant pathogens.

- Among various formulations tested in chickpea, least mortality after germination was recorded with talc (8.26%) followed by invert emulsion-IEF2 (8.55%) based formulations as compared to control (25.50%). However, maximum rhizosphere and rhizoplane population (90 DAS) was observed in invert emulsion.

- Of 20-30 different Trichoderma isolates tested in field, Th-14, Th-89,Th-82, TCMS 43, TCMS 9, TCMS 36 were found most effective in reducing sheath blight by 60 per cent and brown spot disease by 50 per cent and increasing yield by 40 per cent in rice; Th-14 Th-17 Th-3 and TCMS-5 were good in reducing wilt complex by 60 & 65 per cent and increasing yield by 35 & 45 per cent in chickpea and lentil respectively.

- Of various bio-agents, *Pichia guilliermondii* (Y-12) and *Hanseniaspora uvarum* (Y-73) were found good in seedling growth in nursery bed. However, *Trichoderma harzianum* (Th-3) & Y-12 were found significantly better in reducing fruit rot incidence and in increasing yield, as showed minimum fruit rot incidence (13.1 & 13.7%) and fruit yield (13.4 & 13.3 q/ha), respectively as compared to control (16.85% & 10.7 q/ha)

- Large scale field demonstration trials of bio-control technologies under IPM practices were conducted on rice, pea and tomato. The aim was to popularize bio-control technologies by reducing dose as well number of application of fungicides to reduce crop losses caused by diseases. An average number of farmers selected in each year for the demonstration of bio-control technologies were 45 in rice, 17 in pea and 20 farmers in tomato. An average area of about 140 acre in rice, 50 acre in pea and 80 acre in tomato were covered in each year. The average yield of rice under IPM using bio-control technologies was 60q/ha as compared to conventional farmers practices (53q/ha) with an yield increase of 13.5 per cent; the yield obtained in pea was 72q/ha as compared to farmers practices (58q/ha) with

Check Bio-agent treated

an yield increase of 23.5 per cent; in tomato it was 209q/ha as compared to farmers practices (167q/ha) with an yield increase of 24.7 per cent. An average number of farmers selected in each year for the demonstration of bio-control technologies were 45 in rice, 17 in pea and 20 farmers in tomato. The fungicide used under IPM practices using bio-control technologies was half of the conventional practices.

- Large scale demonstration of bio-control technologies was also made on organically cultivated rice cultivars Taraori Basmati and Pusa -1460 during the year 2011-12 & 12-13 by using PBAT-3 in an area of about 1100 acres.Several Organic Farmers Associations like Tarai Organic Farmers Association, *Swatantrata Sangram Sainani Jaivik Krishi Samiti, Rishi Parashar Jaivik Krishi Shodh Samiti* and *Kisan Jaivik Vikas Samiti* from district Udham Singh Nagar have been using PBAT-3 as soil treatment along with FYM/vermicompost, seed treatment/bio-priming, seedling dip treatment and 2-3 foliar spray.

- A lower incidence of the major rice diseases was reported by all the farmers following the above interventions. The above treatments of PBAT-3 followed by need-based application of neem oil @1.5 l/acre and cow urine (@ 20 l/acre effectively suppressed BLB, sheath blight stem borers and hoppers. The average yield of organically cultivated Taraori Basmati was 25 q/ha and that of Pusa-1460 was 35.0 q/ha which was 5.0q/ha less than conventionally grown crop. The organically cultivated Taraori Basmati and Pusa-1460 fetched a higher price of Rs. 400-600 per q when compared to conventionally grown crop.

- To popularize bio-control technologies under IPM field demonstrations were laid at 84 farmers at hills on different vegetables like tomato, chilli, capsicum, cabbage, pea, onion and French bean during the year 2010-11. Average values of pooled results revealed that in all the vegetables the bio-control technologies under IPM were found to increase the yields as compared to farmers practice. The fungicide used under IPM practices using bio-control technologies was half of the conventional practices. The results of the trials in different crops is as under:

- An average area of about 10 acre in capsicum, 5 acre each in brinjal and cabbage,10 acre each in pea and French bean, 2 acre each in onion and okra were covered under demonstration. The average yield of capsicum under IPM using bio-control technologies was 77.5 q/ha as compared to conventional farmers practices (58.2q/ha) with an yield increase of 33.2 per cent; The yield obtained in pea was 84.6q/ha as compared to farmers practices (62.5q/ha) with an yield increase of 26.1 per cent; in tomato it was 195.4q/ha as compared to farmers practices (160.2q/ha) with an yield increase of 21.3 per cent; in onion it was 281.5q/ha as compared to farmers practices (250.5/ha) with an yield increase of 12.4; per cent; in okra it was 118q/ha as compared to farmers practices (36.5q/ha) with an yield increase of 65.0 per cent; and in French bean it was 83.9 q/ha as compared to farmers practices (63.5 q/ha) with an yield increase of 63.5 per cent. The fungicide used under IPM practices using bio-control technologies was half of the conventional practices

- Under TSP programme, during Kharif season (2014) and Rabi season (2014-15), a total of 531 farmers from four blocks and 28 villages were adopted, provided inputs and trained to adopt common minimum programme to reduce the pesticide application in growing vegetables. Basically women tribal farmers were encouraged to use bio-agents as bio-pesticides and as bio-fertilizers in their kitchen gardens so that they can get healthy vegetables and fruits for their families. Capacity building and creating awareness amongst the tribal and small scale farmers were done by demonstrating the method of application of bio-pesticides in crops,

distribution of inputs, trainings, gosthies and regular visits at farmers' fields.

- Biocontrol Laboratory at Pantnagar has been notified by the Directorate of Plant Quarantine and Storage, Government of India for Quality Evaluation of Biocontrol Agents. Department of Biotechnology also notified Biocontrol lab as a Referral Lab for the biocontrol agents. Subsequently, Government of India declared Biocontrol Lab, Pantnagar as 'Central Insecticide Lab' in respect of bio-pesticides (The Gazette of India G.S.R. 756(E); No. 17-6/2006-PP.I).

- The *Trichoderma/ Pseudomonas* (1kg powder preparation/ q compost) was properly mixed with well decomposed compost. Kept it in moist condition at 20-30^{0}C for 15-20 days by covering it with rice straw or any other substrate. The compost colonized with bio-agents is used as soil application.The technology is transferred and being used by Organic growers of the Tarai region and hills of the Uttarakhand.The enriched composts showed higher content of humic matter, phosphorus and micronutrients and being used as biopesticide and biofertilizers for over all crop vigour and management of soil borne plant pathogens

- Seeds are treated with bio-agents and kept in moist condition for at least 24 hrs. at 25-30^{0}C sporulation and colonization of bio-agents on spermosphere. The method is very effective in improving seed germination, growth promotion and colonization in rhizosphere and rhizoplane and in ISR activity and is being used by the farmers for the management of seed, seedling and soil borne plant pathogens.

- Developed five formulations of bio-agents *viz.*, Pant Bio-control Agent -1 (*T. harzianum* -14), Pant Bio-control Agent- 2 (*P. fluorescens*-PBAP-2), Pant Bio-control Agent -3 (*T. harzianum*-14 + *P. fluorescens* -173), Pant Bio-control Agent -4 (*P. fluorescens* PBAP-2 + 3) Pant Bio-control Agent -5 (*Beauveria bassiana* -1). The farmers of the region and members of Tarai Organic Farmers Association of the Uttarakhand are using Pant Bio-control Agent -3 for the management of plant diseases and improvement of soil and crop health under organic farming and IPM programme in various crops like rice, pea, chickpea, lentil, vegetables (tomato, chilli, capsicum, brinjal, cucurbits), fruits, medicinal and flowering plants and in nurseries. More than 1500 farmers of Uttarakhand (hills and plains) have been benefitted in improving their yield by using these formulations.Supply of an average of 2 ton/ year bio-agents formulations to the farmers as per demand.

- The key elements of the Common Minimum Programme include soil solarization vermin-composting, use of pant bioagent-3 as seed treatment, seedling dip treatment, soil drenching and foliar sprays. CMP farmers has reduced cost of production, minimized losses due to pests and diseases, increased benefit-cost ratio and raised value added crop. CMP has been extended to over 2500 farmers from over 95 villages in Uttarakhand hills (hill and mountain agro-ecosystem) through 124 trainings (farmers' field schools).

Sustainability: Through adoption of bio-control technologies, losses through seed and soil borne diseases is sternly curtailed. The eventual aim was to raise healthy plant, which could endure the attacks of biotic and abiotic agents through maintenance of soil microbial diversity and by creating suitable conditions for their growth and development. Thus, this '**zero**' or **'low cost technology'** while on one hand offers a solution to the recurrent disease and pest problems, on the other hand it falls within the framework of organic farming, which is the State policy. Under crop diversification

plan underway in the State, off-season vegetable cultivation is poised to play a unique role in the small farming system in Uttarakhand where bio-control technologies have demonstrated to be indispensable.

❖ Management efficiency indicators viz. funds generated through sale of produce/products/ services.

a. Revenue generation through sale of produce/ products/services:

Rs 0.70-0.80 lac per year through sale of bio-agent formulations

b. Internet connectivity at all centres- Yes

c. Bandwidth at Hqrs. and its centres

d. Computer literacy of scientific staff -100 per cent

e. Scientist sent for training

Linkages with farmers, KVKs, NGOs, Sugar mills, State Dept of Agriculture/Horticulture, Bio pesticide industries. Other Universities/ institutes was given for the past 5 years**.** Since last five years bio-control technologies have been adapted by more than 2500 farmers from 296 villages in 38 blocks of Uttarakhand covering an area of about 1500 ha. More than 5000 demonstrations on key elements of bio-control have been successfully put on display at the farmers fields. A total of 125 trainings on bio-control have been accomplished engendering 2500 beneficiaries.

The demonstrations and trainings were conducted with the help of KVKs staff and extension staff of the university. Depending on the extent of damage to the soil ecology through indiscriminate use of chemicals, varying degree of success has been achieved. However, with continuous adoption of bio-control technologies achievement rate could be quite high. Through the adoption of bio-control technologies farmers have reduced their cost of production substantially and have minimized losses due to pests and diseases resulting healthy crop with increased benefit-cost ratio.

❖ Success story of adaptation of bio-control technologies

✓ Ravindera Mohan Sharma , village Bhavan Singh Navara , Nanital grows rice wheat, brinjal, tomato as well as ornamental crops in 12 acre land. Before 2008, he used to spend Rs. 30000 per year on chemical pesticides which is reduced to less than half after adopting bio-control technologies. Now he is interested in adopting organic farming. He was awarded by Uttrakhand government in the year of 2011 for his valuable contribution

✓ Mr. Rebhader Joshi, village Bakullia , Nainital grows rice, wheat, tomato and cabbage in 1 acre land. Before adopting this programme, he used to apply 75 kg urea and 75 kg DAP per year. But within three years after adopting bio-intensive technologies, the input of chemical fertilizers is reduced to 50 kg per year. The expenditure on chemical pesticides

Soil solarization

Production of bio-control agent

Vermi-compost

which was Rs. 5000 per year is now reduced to Rs. 3000 per year.

- ✓ Mr. Girish Chandra Joshi, village, Kishanpur Shakullia, Nainital using 3 acre land for growing crops . Before adoption of IPM programme he used to apply 2 q urea and 2q DAP as well as chemical pesticides costing about Rs. 8000. But now he is using less than half of the fertilizer and pesticides and earning additional income of Rs. 20,000 by the use of IPM technology in tomato crop .
- ✓ Mr. Hement Singh Bisht, village Nathupur , Nainital grows tomato, cabbage, brinjal, rice, mustard, wheat, sugarcane and pea in 2.5 ha land and got associated with IPM programme in 2009. Presently he is earning an additional income of Rs. 50,000 after getting linked with this IPM programme.
- ✓ Kailash Kabdwal and Chandrashekhar Kabadwal, village Dhanpur, Nainital grows crops in 2.5 ha land. They participated in training under IPM programme in 2009 and were highly influenced. Since then they are using IPM programme for getting higher yield and healthy produce.
- ✓ Mr. Mahesh Chandra Tiwari , village Balluti , Nainital grows cereals and vegetables in 3.5 acre land, before being associated with IPM programme the area under rice, wheat and maize cultivation was more, since last three years, there is drastic change in his cultivation pattern and shifted more towards vegetables production. Before 2008, he was applying 2q urea and 5 q DAP per year and the cost on chemical pesticides was more than 10,000 per year. Now, he is using only 40 kg Urea and 2q DAP and reduced the consumption of pesticides less than half. In four years, his income has increased two times by the use of IPM.
- ✓ Mr. Indal Singh Mehta, village Devla Malla, Naintal grows vegetables (tomato, ginger, pea) in 4.0 acre land. He is associated with bio-control programme since last five years. Initially he used to spend Rs. 25000 per year on pesticides and fertilizers but after adopting bio-control technologies he reduced the cost and spending Rs. 4000 per year.
- ✓ All these farmers are fulfilling the crop requirements by the application of bio-control agents, cow urine ,vermicompost, decomposed cow dung , FYM and enriched vermicompost and decomposed cow dung (colonized with bio-agents) on his agricultural land with the result they are getting healthy produce.

❖ Human Resource Development programmes- manpower and other achievements:

- ✓ Objectives/targets vs. Achievement made- 100%
- ✓ Technologies developed and their impact on increasing productivity/income outstanding

2. Research Publications:

Shukla, N., Awasthi, R.P., Rawat, L., and Kumar, J. 2014. Seed biopriming with drought tolerant isolates of *Trichoderma harzianum* promote growth and drought tolerance in *Triticum aestivum* L. *Annals of Applied Biology* DOI: 10.1111/aab.12160. (7.96)

Vinod Kumar, C.S. Mathela, A.K. Tewari and K.S. Bisht (2014). *In- vitro* inhibition activity of essential oils from some Lamiaceae species against phytopathogenic fungi. *Pesticide Biochemistry and Physiology.* 114:

67–71. (8.01)

Vinod Kumar, C.S. Mathela , Geeta Tewari , Darshan Singh , A.K. Tewari , K.S. Bisht (2014). Chemical composition and antifungal activity of essential oils from three Himalayan Erigeron species. *LWT - Food Science and Technology.* 56 : 278-283 (7.35)

Saxena, D.; Tewari, A.K. and Rai, D. (2014). The *in vitro* effect of some commonly used fungicides, insecticides and herbicides for their compatibility with *Trichoderma harzianum* PBT23. *World Applied Sciences Journal* 31 (4): 444-448. (Impact factor 0.23)

T. A. Sofi ,Tewari,A. K., . Razdan V. K and. Koul, V. K. (2014). Long term effect of soil solarization on soil properties and cauliflower vigor. *Phytoparasitica*, 42 (1): 11-14. (7.3)

Shukla, N., Awasthi, R.P., Rawat, L., and Kumar, J. 2012. Biochemical and physiological response of ric (*Oryza sativa* L.) as influenced by *Trichoderma harzianum* under drought stress. *Plant Physiology and Biochemistry,* **54** : 78-88. (8.35)

Rawat, L., Singh, Y., Shukla, N. and Kumar, J. 2012. Seed biopriming with salinity tolerant isolates of *Trichoderma harzianum* alleviates salt stress in rice (*Oryza sativa* L.): growth, physiological and biochemical characteristics. *Journal of Plant Pathology,* **94** (2): 353-365. (6.77)

Rawat, A., Rawat, L., Negi, Y. and Kumar, J. 2012. Effect of population density of *Rhizoctonia solani* on biocontrol ability of *Trichoderma harzianum* in Frenchbean. *VEGETOS,* **25** (1): 117-124. (6.04)

Rawat, L., Singh, Y., Shukla, N. and Kumar, J. 2011. Alleviation of the adverse effects of salinity stress in wheat (*Triticum aestivum* L.) by seed biopriming with salinity tolerant isolates of *Trichoderma harzianum*. Plant and Soil 347 (1): 387-400. (9.24)

Negi, Y., Garg, S.K., and Kumar, J. 2011. Genetic diversity among cold-tolerant fluorescent Pseudomonas isolates from Indian Himalayas and their characterization for biocontrol and plant growth promotion activities. *J. Plant Growth Regulation*. 30(2):128-143. (8.06)

Patents developed, commercialized and royalty earned through public-private partnership: Methodology for mass multiplication of *Trichoderma/ Pseudomonas* on decomposed cow dung//FYM/ vermicompost is patented and transferred to farmers (Patent No: 242067, 2010).

3. Thesis research:

A. Ph.D. Theses:

1. Deepika Saxena 2013. Studies on mass production technology and development of *Trichoderma harzianum* (Th 15) formulations for optimum shelf life. to GBPUAT under supervision of Dr. A.K.Tewari.
2. Vandana Pandey 2013. Studies on biotic induces resistance against Alternaria blight of mustard. to GBPUAT under supervision of Dr. A.K.Tewari.
3. Kahkashan Arzoo 2014. Fluorescent *Pseudomonas* and *Bacillus* spp. as potential biocontrol agents and induces of defense in wheat against Spot blotch caused by *Bipolaris* spp. to GBPUAT under supervision of Dr. A.K.Tewari
4. Erayya 2014. Designation a Triple combination of Copper Trichoderma and Chitosan and its Evaluation against late blight of potato. to GBPUAT under supervision of Dr. J.Kumar
5. Dinesh Rai 2015. Studies on bio formulations based on *Trichoderma harzianum* (TH-14). to GBPUAT under supervision of Dr. A.K.Tewari
6. NItish Rattan Bhardwaj 2016. Elucidation the role of *Trichoderma* in the triple combination

'Copper-Chitosan-Trichoderma' for the management of late blight disease of potato (*Solanum tuberosum* L.). to GBPUAT under supervision of Dr. J.Kumar

B. M.Sc. Thesis:

1. Meenakshi Dwivedi 2014. Selection of growth promoting *Trichoderma* strains for crop improvement under sustainable Agriculture. to GBPUAT under supervision of Dr. A.K.Tewari
2. Neha Upadhyay 2015. Evaluation of *Trichoderma* and *Pseudomonas fluorescens* isolates for the management of plant mortality in chickpea caused by *Fusarium oxysporum* f.sp. *ciceri*. to GBPUAT under supervision of Dr. A.K.Tewari
3. Richa Bhatt 2016. Evaluation of potential biocontrol agents for the management of sheath blight of rice. to GBPUAT under supervision of Dr. Roopali Sharma
4. Bhupesh C Kabdwal 2016. Management of major diseases of tomato using bio-intensive approaches in Golapar area of district Nainital. to GBPUAT under supervision of Dr. Roopali Sharma.
5. Sourav Kumar Modak 2017. Potential of *Brassica juncea* as bio-fumigant for the management of damping off in tomato. to GBPUAT under supervision of Dr. Roopali Sharma.

4. Future Thrusts:

1. Isolation and characterization of potential antagonists for spermosphere, rhizosphere, rhizoplane and phyllosphere competent and tolerant to abiotic stresses like, temperature, water potential and pH to increase efficacy and their use in different geographical regions.
2. To screen out/develop resistant/tolerant potential *Trichoderma* isolates against commonly used biocides for their use under IDM/ IPM programme
3. To develop marker for the identification of *Trichoderma* asperellum strains Th-14 and *Pseudomonas* fluorescens strain psf 173.
4. To develop consortium using promising *Trichoderma* and *Pseudomonas* isolates to increase efficacy under field conditions
5. To develop delivery methods for the management of foliar diseases
6. To popularize biocontrol technologies at the end of growers

To develop formulations that contains very high CFU to be used for foliar application and drip irrigation