CHAPTER-2
REVIEW OF LITRETURE

Present this thesis entitled Efficacy of *Pseudomonas fluorescens* and *Bacillus subtilis* against *Fusarium oxysporum* f.sp. *capsici* and *Meloidogyne incognita* of chilli related available information in general has been reviewed and which is presented below.

Satija and Hoonda (1987) reported fungicides belonging to different chemical groups were evaluated for their efficacy in controlling damping-off tomato and chili caused by *Fusarium solani* and *Pythium aphanidermatum*. As seed treatment copper oxychloride was the best fungicide in controlling damping-off of the both the tests plants caused by *F. solani*. Whereas for the control of damping-off due to *P. aphanidermatum* MEMC was the best fungicide. However, for controlling damping-off caused by both the fungi MEMC and captan were very promising on tomato and captafol on chill.

Kapoor and Kumar (1991) observed that relative efficacy of three systemic (benomyl, carbendazim and thiophanate-methyl) and three non-systemic (captafol, captan and thiram) fungicides against isolates each of *Fusarium oxysporum* and *F. solani* obtained from tomato was studied using poison food technique. Carbendazim and benomyl were most toxic. *F. solani* isolate KHF-41 was most sensitive, whereas *F. oxysporum* isolate DFO-13 was least sensitive to these fungicides. *F. solani* isolates required 3-5 times more dosages of non-systemic fungicides than *F. oxysporum* isolates. The decreasing order of over all efficacy of different fungicides was carbendazim, benomyl, captatol, thiram, thiophanate-methyl and captan.

Hyun *et al*, (1999) isolated from the culture of an antagonist against *Fusarium oxysporum* f. sp. *sesami, Bacillus polymyxa* strain KB-8, and tested for the control of Fusarium wilt of sesame in greenhouse conditions. Optimum conditions for culturing the antagonist to obtain the maximum antibiotic activity were determined using different culture media, initial medium acidity, and incubation periods, for which yeast–malt extract agar with the initial acidity of pH 5 and over 13 days culture were best. Antibiotic substances
extracted by methanol had 2 main fractions, KB-8A and KB-8B, in thin layer chromatography (TLC) with Rf values of 0.35 and 0.67 in a solvent system of chloroform : methanol = 7 : 3. The fraction KB-8A was purified further by XAD-2, silica gel and Sephadex LH-20 column chromatography, and crystallization. Its minimum inhibitory concentrations (MICs) were 12.8 μg/ml for *F. oxysporum* and *Alternaria mali*, 6.4 μg/ml for *Colletotrichum gloeosporioides* and *Rhizoctonia solani*, and 3.2 μg/ml for *Phytophthora capsici*. Soil drenching of antibiotic KB-8A in the concentrations of 13.0 μg/ml and 26.0 μg/ml effectively inhibited the Fusarium wilt of sesame in a greenhouse test, which appeared to be comparable to the fungicide benlate of 6.5 μg a.i./ml.

Kumar and Dubey (2001) observed that isolates of *Trichoderma viride*, *T. harzianum* and *Gliocladium virens* were screened against a *Fusarium solani* f. sp. *pisi* causing collar rot of pea through dual culture and production of volatile and non-volatile antibiotic substances in vitro. The Ranchi isolate of *T. harzianum* and *G. virens* showed superiority over other isolate in respect of inhibition of mycelial growth of pathogen. *T. harzianum* showed maximum growth around the treated seed followed by *G. virens*, thiram +*G. virens*, capton +*G. virens* and capton +*T. harzianum* which were statistically at par. The seeds treated with capton (1g/kg)+*T. harzianum* (106 spores/ml/10g seed) gave good germination, least disease incidence alone with highest green pod yield, which was statistically similar with seed treated with *T. harzianum* alone, thiram +*T. harzianum*, carboxin +*G. virens* and *G. virens* alone.

Nahar *et al.*, (2004) studied using standard blotter and deep-freezing techniques, seed-borne mycoflora of 40 samples from consignments of *Capsicum annuum* L. (red chillies var. Dhora, imported from India). Of the 47 fungal species *Absidia corymbifera*, *Acremonium fusidioides*, *Aspergillus tamarii*, *Blakeslea* sp., *Cephalophora irregularis*, *Cladosporium accacicola*, *Scopulariopsis* sp., *Streptomyces* sp., *Tritirachium* sp., and *Ulocladium tuberculatum* have been not reported before from seeds as well as pericarp of *C. annuum*.
Kurundkar and Mahajan (2005) obtained from eighteen fungal isolates were rhizosphere samples of various crops grown in Marathwada region of Maharashtra State. Antagonistic nature of these isolates against *Fusarium oxysporum* f. sp. *carthami* was studied in dual culture on potato dextrose agar (PDA) medium in the laboratory. All the fungal isolates reduced growth of the pathogen up to 9 days of incubation period. Maximum inhibition was observed in *Aspergillus niger* followed by *A. flovars* and *Trichoderma* sp. The former two fungi were fast growing and put forth competition for growth with the pathogen.

Singh *et al.*, (2005) reported that different transplanting dates influenced chilli wilt caused by *Fusarium oxysporum* and *F. solani*, incidence of wilt and fruit yield was significantly influenced during both the years (2001 and 2002). Late transplanting (19th August) was significantly effective in reducing the disease incidence to 14.33 and 17.77 % in kharif 2001 and 2002, respectively as compared to early transplanting (June, 20) with the values 41.77 and 42.88%. Maximum fruit yield of 1851.1 kg / ha-1 and 1856.6 kg / ha-1 was recorded in kharif 2001 and 2002, respectively in the crop transplanted on July 19th while minimum in the crop transplanted on 19th August in both the years. Soil moisture particularly correlated with high chilli wilt.

Sultana *et al.*, (2006) reported that an application of *Pseudomonas aeruginosa*, a plant growth promoting rhizobacterium alone or with crustacean chitin, fungicides (benlate/captan) or *Paecilomyces lilacinus* (a biocontrol agent) significantly suppressed *Macrophomina phaseolina*, *Rhizoctonia solani*, *Fusarium oxysporum* and *F. solani* attacking roots of chilli. *Paecilomyces lilacinus*, an egg parasite of root knot and cyst nematodes, also caused significant suppression of root rot pathogens. *Pseudomonas aeruginosa* was found to be less effective against *M. phaseolina*, but more effective against *F. solani*, than benlate and captan. *Pseudomonas aeruginosa* and *P. lilacinus* together on crustacean waste powder produced better plant growth than when used alone. The use of crustacean waste powder resulted in better plant growth than the use of pure chitin.
Jha and Jalali (2006) observed the root rot disease of pea (*Pisum sativum* L.) incited by *Fusarium solani* f. sp. *pisi* cause considerable crop losses in northern India. The fungal isolates of pea rhizosphere were evaluated for their biocontrol potential against *Fusarium solani* f. sp. *Pisi* under *in vitro* study (dual culture method) and sick soil (pot) condition. Under in vitro study, isolate *Trichoderma viride* showed the strongest antagonistic activity towards *F. solani* f. sp. *pisi* in dual culture followed by *Aspergillus niger*. *A. terreus*, *A. soydowi*, *A. flavus* and *spicaria sylvatica*. The two highly efficient antagonists. *T. viride* and *A. niger* were studied individually and in combination in relation to the biocontrol of pea root rot under pathogen sick soil (pot) condition. Both the antagonists controlled the disease more efficiently when used individually than those used in combination *T. viride* and *A. niger* applied individually @15 gm/5kg sick soil recorded the disease severity of 33.3% and 40% respectively, while the disease severity under untreated sick soil was 96.6%.

Sahi and Khalid (2007) evaluated *Trichoderma* viz., *Trichoderma viride*, *T. harzianum*, *T. koningii*, *T. aureoviride* and *T. pseudokoningii* for their *in vitro* antagonistic potential against *Fusarium oxysporum*, the cause of wilt disease in sweet peppers (*Capsicum annum*). Among the *Trichoderma* species *T. viride* showed the best performance *in vitro* biological control of *Fusarium oxysporum* followed by *T. harzianum*, *T. aureoviride*, *T. koningii* and *T. pseudokoningii*, respectively, resulting in 62, 36, 24, 18 and 6% reduction in colony growth of the test pathogenic fungus respectively.

Jiskani *et al*, (2007) survey of tomato fields of Hyderabad district to estimate the incidence of damping –off disease. Maximum disease incidence was recorded at village Darya Khan Nahiyoun (65.0%) followed by Khatian Satation (60.0%) and the minimum were at Khesano Mori (35.0%). *Rhizoctonia solani* Kuhn was isolate as the predominant damping –off fungus with highest frequency (60%) from the over all tomato field followed by *Fusarium oxysporium* f.sp.lycopersici. *Macrophomina phaseolina*. *Alternaria solani* and Verticillium albo-atrum. Pathogenicity test of *Rhizoctonia solani* was conducted by artificially inoculating the steam sterilized soil. The maximum number of infected plants emerged from the infested soil after 30 artificially infested soil where as 13.33% was observed in un-inoculated soil. Four fungicides viz., Topsin-M.Benlate.
Copper oxychloride and Derosal were applied as soil drench. Topsin-M significantly increased the germination, number of plants and plant growth followed by Benlate, Copper oxychloride and Derosal.

Ciampi et al., (2009) reported that Calla (Zantedeschia aethiopica (L.) Spreng.) is a flower that is conquering international markets. It is very important to maintain the healthiness of the crop during its development in order to obtain high quality plants that meet the demands of the markets. The objective of this investigation was to determine the etiological agent(s) of a pathology never observed before in Chile that causes vascular wilt during the cultivation of colored calla developed under greenhouse conditions. Fungal isolates were collected from infected plants. Pathogenicity tests, microscopic observations, and scanning electronic microscopy evaluations were also conducted. Healthy calla tubers were inoculated with isolates of the genus *Fusarium* Link. Plants grown during 5 months in a climatic chamber showed five classes of symptoms: damping off, dwarfism, intense wilting, mild wilting and no symptoms. The isolates were identified at the species level and it was found that 20% was *Fusarium solani* (Mart.) Sacc. And 80% was *Fusarium oxysporum* Schltldl. Results and collected evidence these two new species that affect production of calla under greenhouse conditions in Chile.

Bajpai et al., (2009) observed that mycelial growth inhibition of test plant pathogens, such as *Botrytis cinerea, Colletotrichum capsici, Fusarium oxysporum, Fusarium solani, Phytophthora capsici, Rhizoctonia solani* and *Sclerotinia sclerotiorum*, was measured in vitro. bDHA (5 ll disc-1) inhibited 55.30–65.90% fungal mycelium radial growth of all the tested plant pathogens. Minimum inhibitory concentrations (MICs) of bDHA against the tested plant pathogens were found in the range of 125–500 lg ml-1. Also, bDHA had a strong detrimental effect on spore germination for all the tested plant pathogens. Further, three plant pathogenic fungi, namely *C. capsici, F. oxysporum* and *P. capsici*, were subjected to an in vivo antifungal screening. bDHA at higher concentrations revealed a promising antifungal effect in vivo as compared to the positive control oligochitosan. Furthermore, elaborative study of GC-MS analysis was conducted on bioconverted oil extract of DHA to identify the transformation products present in
bDHA. The results of this study indicate that the oil extract of bDHA has potential value of industrial significance to control plant pathogenic fungi.

Jabeen et al., (2009) reported that *Fusarium* wilt is a principle disease of chilli crop in Kashmir and has assumed a serious proportion. The varieties identified as resistant to a particular pathogen may not have desirable traits, however, can be used as donors. Two resistant and 6 susceptible chilli (*Capsicum annum* L.) genotypes and their twelve F1 hybrids showing variable degree of resistance to *Fusarium* wilt were analyzed for phenols and phenolic enzymes, under both uninoculated and inoculated conditions at different growth stages. Generally total phenols ortho-dihydroxy phenols and the enzyme activity were invariably high in resistant parents and hybrids irrespective of growth stages, while, in case of susceptible parents the phenols content and enzyme activities were comparatively less. There existed a positive correlation between the host resistance and the amount of phenols and increased enzyme activities while it was almost the opposite in susceptible lines. The positive association of higher phenols and enzymes with resistance could be of immense value for early and quick identification of resistant genotypes during screening of large populations.

Sultana and Ghaffar (2010) studied *In vitro* and *In vivo* the effect of fungicides, microbial antagonists and oilcakes in the control of *Fusarium solani* the cause of seed rot, seedling and root infection on bottle gourd, bitter gourd and cucumber. Complete inhibition of colony growth of *F. solani* was observed where fungicides viz., Aliette, Benlate and Carbendazim @ 100 ppm were used. Carbendazim completely eradicated seed borne infection of *F. solani* in bitter gourd and gave maximum reduction in cucumber and bottle gourd. Root infection was completely checked by benlate and carbendazim in bitter gourd and was best controlled by Aliette, Topsin-M and carbendazim in bottle gourd and cucumber. *F. solani* infested seeds of bottle gourd, cucumber and bitter gourd reduced seedling mortality and root infection when sown in mustard and neem cake amended soil. Mustard cake was found most effective at all ratios followed by neem and castor cake.
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Yelmane et al., (2010) used the extracts of different organics of neem cake, mustard cake, FYM, groundnut cake, poultry manure, press mud, castor cake and coconut cake were tested against *F. solani* by poisoned food technique in *in vitro*. Least growth of the pathogen was recorded in the extracts of neem cake showing excellent inhibitory effect *i.e* 59.8 % against *F. solani*. Next best in order of merit was mustard cake (52.61 %) followed by FYM (49.40 %), groundnut cake (44.80 %), poultry manure (42.29 %), and least by other cakes.

Akhtar et al., (2010) observed the effects of *Bacillus pumilus*, *Pseudomonas alcaligenes*, and *Rhizobium* sp. on wilt disease caused by *Fusarium oxysporum* f. sp. *lentis* and on the growth of lentil. Inoculation with *F. oxysporum* caused significant wilting, and reduced plant growth, the number of pods, and nodulation. Inoculation with *B. pumilus* together with *P. alcaligenes* caused a greater increase in plant growth, number of pods, nodulation, and root colonization by rhizobacteria, and also reduced *Fusarium* wilting to a greater degree than did individual inoculation. Use of *Rhizobium* sp. resulted in a greater increase in plant growth, number of pods, and nodulation, and reduced wilting more than *B. pumilus* did. Combined application of *B. pumilus* and *P. alcaligenes* with *Rhizobium* sp. resulted in the greatest increase in plant growth, number of pods,
nodulation, and root colonization by rhizobacteria, and also reduced wilting in *Fusarium*-inoculated plants.

Suryanto *et al.*, (2010) reported that biological control of plant disease using antagonistic microorganism has been obtaining much attention and implemented for decades. One of the potential microorganisms used in this strategy is chitinolytic bacteria. Utilization of this bacteria ranges from cell life, enzymes, genes, or other metabolites. They examined the ability of chitinolytic bacteria as a bio-control agent of *Fusarium* wilt of red chili (*Capsicum annuum* L.) seedlings. The ability of chitinolytic bacteria to suppress the disease was evaluated by soaking red chili seeds in the bacterial isolates solution for 30 minutes prior seedling. Percentage of seedling of treated chili seed at end of study (4-weeks) ranging from 46 to 82.14%. Relative reduction of the seedling damping-off was observed in all bacterial treatment ranged from 28.57 to 60.71%. Furthermore, manifestation of bacterial suppression to *Fusarium* wilt was also exhibited by increasing of seedling height (ranged from 7.33 to 7.87 cm compared to 6.88 cm) and dry-weight (ranged from 2.7 to 4.3 mg compared to 2.3 mg). However, no significant effect was observed in leaf number. Then, from all chitinolytic isolates tested, BK08 was the most potential candidate for biological control agent of *Fusarium* wilt in chili seedling.

Wongpiaa and Lomthaisong (2010) reported that wilt disease caused by *Fusarium oxysporum* f. sp. *capsici* is a major problem of chilli pepper production worldwide that calls for a better understanding of defensive mechanisms in the chilli plant. They used a proteomic technique to investigate protein responses of chilli pepper to *F. oxysporum* f. sp. *capsici*. Two cultivars of resistant (Mae Ping 80) and susceptible (Long Chilli 455) plants were cultured in vitro. Chilli plants at 6-week growth were then infected with a suspension of *F. oxysporum* f. sp. *capsici* or distilled water used as a control. After 48 h of infection, proteins were extracted and analysed using 2DE to identify the responsive proteins. At least 9 spots were differentially expressed in the resistant cultivar (5 increasing, 4 decreasing) and 1 supplementary; while 15 increasing, 11 decreasing, and 11 supplementary protein spots were found in the susceptible cultivar. These proteins were then identified by MALDI-TOF MS combined with bioinformatics methods. Some of the induced proteins e.g., NADPH HC toxin reductase, serine/threonine protein kinase,
and 1-aminocyclopropane-1-carboxylate synthase 3 are involved in plant defence mechanism. In order to determine the Fusarium wilt protective proteins in chilli plant, the protein patterns of healthy resistance were compared with those of susceptible cultivars. Interestingly, resistance showed higher expression of proteins related to ROS detoxification. Moreover, the ability of chilli plant to resist Fusarium wilt disease was related to the expression of non-inducible immunity 1 protein.

Monaim et al., (2010) reported that ten isolates of Fusarium spp were isolated from pepper plants collected from different locations in New Valley Governorate, Egypt. Fusarium solani isolate FP2 and F. oxysporum isolate FP4 were highly pathogenic isolates but the other isolates moderate or less pathogenic to pepper plants (cv. Anaheim-M). The four antioxidant compounds (coumaric acid, citric acid, propylgalate and salicylic acid each at 100 and 200 ppm) were evaluated for their in vitro and in vivo agonist to Fusarium pathogenic isolates caused root rot and wilt diseases in pepper plants. All tested antioxidant compounds reduced damping-off, root rot/wilt and area under root rot/wilt progress curve when used as seed soaking, seedling soaking, and soil drench especially at 200 ppm under greenhouse and field conditions compared with untreated plants. All chemicals increased fresh and dry weight of seedling grown in soil drenching or seed treatment with any antioxidants. At the same time, all tested chemicals significantly increase plant growth parameters i.e plant length, plant branching, and total yield per plant in case of seedling soaking or soil drench. In general, propylgalate at 200 ppm was more efficient in reducing infection with damping-off, root rot and wilt diseases as well as increasing the seedling fresh weight, dry weight, plant length, plant branching, number of pod plant⁻¹ and pod yield plant⁻¹. On the other hand, all tested antioxidants had less or no effect on mycelial dry weight and mycelial leaner growth. On the contrary, all chemicals much reduced spore formation in both Fusarium species at 100 or 200 ppm and the inhibitory effect of antioxidants increased with increasing their concentrations.

Koppula et al.,(2010) tried an approach towards the development of eco-friendly antifungal compounds for controlling crop diseases using methanol solvent extracts of twenty South Indian medicinal plants against three important phytopathogenic fungi (Colletotrichum capsici, Phytophthora aphanidermatum and Fusarium oxysporum)
associated with different diseases in Chilli (Capsicum annum L.). Among the twenty plants tested methanolic extracts of Morus alba followed by Siegesbeckia orientalis, Catheranthus roseus, Emblica officinalis, Hildegardia populifolia and Elephantopus scaber plant species recorded highly significant antifungal activity against all pathogens, and further it was suggested that plant species are potential medicinal plants for the management of phytopathogenic microorganisms. The antifungal components from these plants could be used in developing novel fungicides (biopesticides) for the diseases caused by Colletotrichum capsici, Phytophthora aphanidermatum and Fusarium oxysporum (plant pathogen).

Muthukumar et al., (2010) isolated nine bacterial from stem and root portions of chillies and tested for their efficacy against Phytophthora aphanidermatum (Edson) Fitzp. inciting chilli damping-off under glasshouse condition. Out of these nine bacterial endophytes, EBC 5, EBC 7 and EBC 6 recorded the minimum mycelial growth (28.00, 30.66 and 33.33 mm, respectively) with maximum inhibition zone of (12.33, 11.66 and 11.08 mm, respectively) of pathogen over control. In the present study, chilli seeds treated with these endophytes in combination (EBC 5 and EBC 6) recorded the lowest incidence of pre and post-emergence damping-off (9.10 and 12.33 per cent, respectively) at seven and 14 days after sowing when compared to individual treatment. This was followed by seed treatment with EBC 5 and EBC 7 in combination. The combination (EBC 5 and EBC 6) treatment also increased the germination percentage, shoot length and root length of chilli plants significantly (87.66%, 13.89 and 4.0 cm, respectively). Further, this writer concluded that the combination of endophytes were more effective in controlling disease when compared to individual treatments.

Otroshy et al., (2011) tested an efficient procedure of in vitro plant regeneration through direct shoot bud induction for different explants of Capsicum annum L. The best performance was observed for cotyledons on MS medium containing 6 mg L⁻¹ 6-benzylaminopurine and 1 mg L⁻¹ indole-3- butyric acid. Regeneration for other types of explants (i.e., shoot tip, hypocotyl and root) did not show satisfactory results because the explants did not develop into normal shoots but instead developed into calli after 12 days of culture. Histochemical analysis showed that only the cotyledons revealed a direct
induction of more teralogical protuberances that arose around the cut end of the explants. Elongation of shoot buds was obtained on MS medium containing 1 mg L\(^{-1}\) BAP +0.5 mg L\(^{-1}\) indole-3-butyric acid. Regenerated shoots rooted best on the same medium on which also elongation was realized. After hardening, the rooted plants were transferred to the green house conditions where they grew, matured and flowered normally with a survival rate of 85%.

Oostendorp and Sikor(1990) reported that a application of bacteria to the root surface of sugar beet seedlings did not alter the migration of \(H.\) schachtii second-stage juveniles towards the root. The hatch stimulating activity of root exudates of sugar beets was reduced \((P = 0.05)\) after treatment of exudates with seven of eight isolates tested. Nematode penetration into the root was reduced \((P = 0.05)\) by six of the eight isolates. Bacterial metabolites were not toxic to Panagrellus redivivus. The results indicate marked differences in the mode-of-action of different bacterial isolates.

Ramakrishnan et al.,(1996) studied the effect of bio-fertilizers, viz. azolla and azospirillum on root-knot nematode, \(Meloidogyne incognita\) has revealed that okra plants treated with dry azolla (3%) exhibited enhanced growth of shoot length, fresh and dry weight of shoot and root and pot yield. Maximum reduction in number of adult females, egg masses, eggs per egg mass and soil nematode population was recorded in the plants treated with dry azolla (3%). In general all the treatments having bio-fertilizers differed significantly compared to untreated control in reducing root-knot nematode, and increasing plant growth in okra.

Khan et al., (2000) conducted a survey of nematode communities associated with chilli fields in eight localities of lower sindh. In all eight species were recorded viz., \(Meloidogyne\) sp. Larvae: \(Helicotylenchus indicus; Pratylenchus penetrans; Tylenchus sp.\) Larvae; \(Pratylenchus throni; Tylenchorhynchus annulatus; Psilenchus hilarulus; Hoplolaimus indicus and Aphelenchus avenae.\) A principal component ordination showed the relationships between localities and the species. Cluster analysis revealed the grouping of the nematode communities. Two main groups could be recognized, a small group having large populations of \(Meloidogyne\) sp. larvae and a large group comprising
of communities with saprophytic nematodes and parasitic species such as *Helicotylenchus indicus*, *Tylenchorhynchus annulatus* and *Pratylenchus* spp. With variable densities.

Meyer *et al.*, (2002) reported that numerous microbes are antagonistic to plant-parasitic nematodes and soilborne plant-pathogenic fungi, but few of these organisms are commercially available for management of these pathogens. Inconsistent performance of applied biocontrol agents has proven to be a primary obstacle to the development of successful commercial products. One of the strategies for overcoming inconsistent performance is to combine the disease-suppressive activity of two (or more) beneficial microbes in a biocontrol preparation. Such combinations have potential for more extensive colonization of the rhizosphere, more consistent expression of beneficial traits under a broad range of soil conditions, and antagonism to a larger number of plant pests or pathogens than strains applied individually. Conversely, microbes applied in combination also may have antagonistic interactions with each other. Increased, decreased, and unaltered suppression of the target pathogen or pest has been observed when biocontrol microbes have been applied in combination. Unfortunately, the ecological basis for increased or decreased suppression has not been determined in many cases and needs further consideration. The complexity of interactions involved in the application of multiple organisms for biological control has slowed progress toward development of successful formulations. However, this approach has potential for overcoming some of the efficacy problems that occur with application of individual bio-control agents.

Cannayane and Rajendran (2002) isolated large groups of bioagents and identified as potential biomolecules in reducing the plant parasitic nematode menace. Biomolecules such as plant growth promoting rhizobacteria (*Pseudomonas* spp. and *Bacillus* spp.), obligate parasite (*Pasteuria* spp.), opportunistic fungi (*Paecilomyces lilacinus*, *Vericillium* spp. and *Trichoderma* spp.), predaceous fungi (*Arthrobobys* spp.) and Vesicular Arbuscular Mycorrhizae fungi have been recognized as most important candidates for reducing different plant parasitic nematode in several crops under varied
agroclimatic conditions. Their effectiveness, mode of action against plant parasitic nematodes and characteristics of a successful biomolecule is reviewed.

Thomas et al., (2004) reported that Meloidogyne incognita-infected and noninfected tubers of yellow nutsedge (Cyperus esculentus) and purple nutsedge (Cyperus rotundus) were treated with 56 L/ha 1,3-dichloropropene (1,3-D) in microplots and subsequently examined for tuber and nematode viability in the greenhouse using a chile pepper (Capsicum annum) bioassay system. The study was conducted three times. Nutsedge tuber viability and M. incognita harbored in both yellow and purple nutsedge tubers were unaffected by 1, 3-D treatment.

Rao et al., (2004) observed the efficacy against the root-knot nematode, Meloidogyne incognita, infecting bell pepper. In the nursery bed, the formulation of P. chlamydospora was significantly more effective at 50 g/m2 than at 25 g/m2 in reducing root galling index and the numbers of nematodes in roots and soil and increasing the percent parasitization of eggs and yield. Seed treatment with P. floescens alone or nursery treatment with P. chlamydospora were also effective. The individual effect of each organism was maximized when both were added together to the nursery bed.

Saravanapriya and Sivakumar (2005) reported that Meloidogyne incognita infecting tomato with five botanicals, viz. leaves of Calotropis gigantean (Linn.) R.Br. ex Ait., Tagetes erecta Linn. And Azadirachta indica A.Juss.; seeds of Citrullus Lanatus (Thunb.) Matsumura & Nakai and Areca catechu Linn. Results showed statistically significant increase in both seed germination as well as seedling establishment in all the treatments when compared with control. Seed treatment with dry powder of C.gigantea leaves gave the highest germination (98.0%) and highpercentage of established seedlings (99.6%).Root dip treatment with leaf extract of C.gigantea resulted in significant reduction of the soil nematode population at 45 days after transplanting and at harvest (87.3% and 90.0%, respectively) and lowest gall index (1.7) with increase in fruit yield, 23.9%.

Pandey et al., (2006) Attempted to control the root knot nematode through the combination of two fungal bio-agents Aspergillus fumigatus and Trichoderm am harzianum,
both collected from eggmasses of root knot infected brinjal plants. The larvicidal, ovicidal and egg parasitisation capacity test were conducted for both fungi by allowing fresh eggmasses into the fungal mat.

Sharma et al. (2006) observed that organic materials such as neem oil smearing (1% w/w) of okra and soil amendment with *Datura stramonium* and *Calotropis procera* leaves 5% (contained alkaloids like Scopolamine/ Hyocin) alone and in combination with kalisena (a commercial formulations of *Aspergillus niger*) bio-agent and biofertilizer, AN 27 SD egg parasitic and toxin producing facultative fungi and *Trichoderma harzianum* as seed treatment (1% w/w) against *M. incognita* showed that *Calotropis sp.* and neem oil alone mitigated root knot galls by 62%. In combined application, reduction in nematode multiplication was not enhanced than the alone treatments. Neem oil, *T. harzianum* and *Calotropis sp.* in combined application affected maximum galling by over 58%. While Kalisena and *Calotropis sp.* combination was not so effective in reducing the number of galls. Plants growth such as shoot length, root and shoot weight was improved in treated soil.

Burkett-Cadena et al.,(2008) conducted studies to test the hypothesis that induction of soil suppressiveness against *Meloidogyne incognita* using rhizobacterial inoculants is related to soil microbial activity and rhizosphere bacterial populations. Commercially-available rhizobacterial inoculants (Equity_, BioYield_, and AgBlend_) and FZB42, strain in the product RhizoVital_, were selected based on elicitation of growth promotion in tomato and pepper in previous tests. The inoculants Equity (multiple strains), BioYield (two strains), and FZB42 induced significant reductions in nematode eggs per gram root, juvenile nematodes per ml of soil, and galls per plant on tomato. AgBlend, containing microbial metabolites, reduced number of galls. Treatment with each of the inoculants also increased root weight. Rhizosphere populations of total bacteria and aerobic endospore-forming bacteria (AEFB) were increased following treatment with AgBlend, BioYield and FZB42. Strain FZB42 had an unique colony morphology, allowing its detection in the rhizosphere where it became the dominant strain. Soil microbial activity, as assessed by fluorescein diacetate hydrolysis, was not affected by inoculants.
Sharma and Pandy (2009) reported that root knot nematode; *Meloidogyne incognita* nematode antagonistic fungi have been studied for their use as biocontrol agents. In the experiment, the potential of fungi *Trichoderma harzianum, Paecilomyces lilacinus* and *Arthrobotrys oligospora* along with natural organic compound (Neem compound mix) to control the nematode; *M. incognita* was evaluated. Also, their potential to control nematodes was compared with that achieved by using the chemical control agent; carbofuran. The fungal agents evaluated significantly controlled nematode population and enhanced plant growth.

Pakeerathan *et al.*, (2009) observed *Meloidogyne incognita* as silent enemies in soil and cause losses up to 80% in heavily infested fields. Stunting, yellowing and a general unthrifty appearance are the symptoms developed above ground slowly over time and remain unnoticed until plants are well developed. Infested tomato wilt or die in hot, dry weather causing losses in yield ranging from 28-68%. A screen house study was conducted to test the effect of different animal manures on the eco-friendly management of *M. incognita* on tomato. Recommended dosage of manures, biological control agent and chemical namaticide were compared with control. The results revealed that goat manure was the best alternatives for the management of *M.incognita* and more or less equally effective to carbofuran. It is not only suppressing the gall formation but also improve crop growth and biomass production. While bio agent, *Trichoderma viride* and poultry manure ranked third and fourth, respectively in managing *M.incognita*. This management study revealed that organic amendments improve that plant growth and check the nematode infestation in

Abbas *et al.* (2009) reported that the nematicidal activity of some spices against *Meloidogyne javanica* root knot nematode was examined. *In vitro* results showed that aqueous extract of *Cuminum cyminum* (100 % w/v) and ethanol extract of *Capsicum annum*, *Cinnamonomum tamala* and *Curcuma longa* (1000 ppm) significantly inhibited egg hatching of *Meloidogyne javanica*. Aqueous extract of *C. longa*, *Nigella sativa* and *Piper nigrum* in 100% w/v whereas ethanol extract of *C. tamala* and *P. nigrum* in 1000 ppm caused appreciable mortality of second stage juveniles of *M. javanica*. Ethanol extract was found better as compared to aqueous extract. The concentration used @ 100% and
1000 ppm were found more effective and produced significant results as compared to 50%, 500 ppm and 250 ppm.

Vetrivelkalai et al. (2010) isolated nineteen endophytic bacterial were obtained from surface-sterilized roots of different crops. Study on the morphological, phenotypic and biochemical characterization of endophytic bacteria revealed that eight isolates viz., EB1 to EB8 belong to the group of *Pseudomonas* sp., ten isolates viz., EB9 to EB18 belong to the group of *Bacillus* sp. and isolate EB19 belongs to *Methylobacterium* sp. On seed bacterization with nineteen endophytic bacterial isolates, four isolates viz., EB3, EB16, EB18 and EB19 significantly enhanced the germination percentage, shoot and root length and vigour index of bhendi seedlings by roll towel technique and pot culture studies. Eight endophytic bacterial isolates were screened for their nematicidal action against *Meloidogyne incognita* under pot culture conditions. The study revealed that the culture filtrates of endophytic bacterial isolates viz., EB3, EB16, EB18 and EB19 significantly reduced the number of adult females, egg masses, eggs/eggmass, root and soil infestation of *M. incognita*. The lowest root gall index (1.00) was registered both in EB16 and EB18 isolates and it was followed by EB19 and EB3 (1.33) compared to untreated control (4.67).

Setiawati et al. (2010) reported that the Root-knot nematode (*Meloidogyne* spp.) and melon thrips (*Thrips palmi* Karny) are two serious pests on potato. These pests are conventionally controlled with synthetic pesticides. Cultural practices based on integrated pest management (IPM) are alternative methods to control these pests. Treatments were implementing IPM and conventional practices. IPM or cultural practices (subsoiling, soil solarization and use of trap crop of marigold *Tagetes erecta*) and conventional practices using synthetic pesticides. The subplots were five potato cultivars. The results showed that applications of cultural practices in combination with potato cultivars reduced *Meloidogyne* spp. population and potato tuber damage by 53.70% and 61.36%, respectively, as well as a significantly decreased thrips population. In the cultural control plots, thrips populations were below the action threshold (10.0 nymphs per leaf), therefore no single application of pesticide was used. This was in contrast to the conventional control treatments where insecticide was sprayed 10 times until harvest.
Population of *T. palmi* on the five potato cultivars differed significantly; the lowest population was found on the cultivars No. 095 (Herta x FLS-17) and 676068/I.1085. The cultural control practices combined with potato cultivar No. 095 (Herta x FLS–17) were the best treatment for controlling *Meloidogyne* spp. and *T. palmi* on potato and also produced the highest yield (31.01 t ha⁻¹).

Chaudhary and Kaul (2010) reported the effect of pre, post and simultaneous applications of *Pasteuria penetrans* to nematode *Meloidogyne incognita* was determined. Time of application of *P. penetrans* to soil was observed to have profound effect on the efficacy of the bacterium and it also affected the plant growth and multiplication of the nematode. The simultaneous application of *P. penetrans* infested soil with *M. incognita* J2 was found to be the most effective in the improving fresh and dry biomass of the chilli crop. This treatment was followed by the seven days prior application of *P. penetrans* to Nematode. The simultaneous application of *P. penetrans* with nematode treatment was found to cause maximum reduction in final population of *M. incognita*. This treatment yielded 45-53% improvement in the various parameters of the fresh and dry biomass of the crop and 71% reduction in final nematode population when compared with the control.

Dangal et al., (2010) conducted pot experiment during July-November 2006 in a glass house at the Institute of Agriculture and Animal Science, Rampur, Chitwan to find out the impact of soil infestation of rice root-knot nematode (*Meloidogyne graminicola* Golden and Birchfield) and flooding on its development and rice yield.

Moon et al., (2010) reported that biological and structural mechanisms of the nematode disease development in chili pepper caused by the root-knot nematode, *Meloidogyne incognita*, were investigated. Out of 39 chili pepper cultivars/lines tested, six were found resistant, while 33 were susceptible to *M. incognita*, of which a susceptible cultivar Chilseongcho and three resistant cultivar/lines CM334, 02G132 and 03G53 with different resistance degrees were selected for microscopic studies on the disease development. Gall formation was greatly reduced in the resistant cultivars/ lines. Nematode penetration occurred both in the susceptible and resistant chili pepper roots; however, the penetration
rates were significantly lowered in the three resistant peppers compared to the susceptible pepper cv. Chilseongcho. In the susceptible pepper, giant cells were extensively formed with no discernible necrosis around the nematode feeding sites. In the highly resistant pepper cultivar CM334, no giant cell was formed, but extensive necrosis formation was observed around the penetrating nematodes. In the other two resistant pepper lines (02G132 and 03G53), both giant cells and prominent necroses were formed, and the necrotic responses appeared to inhibit the further development of giant cells or accelerate their early degeneration. Although the nematode penetration was retarded significantly in the resistant cultivar/lines, all of the above results suggest that the disease resistance of pepper may be related to post-infectional defense mechanisms (nematode growth and development) more than pre-infectional ones (penetration and establishment). Variations in structural modifications in the resistant cultivar/lines may reflect their genetic differences related to the nematode resistance.

Zarina and Shahin (2010) reported that root-knot nematode *Meloidogyne* spp., is one of the most important plant pathogen which reduces yield and biomass of crops in different parts of the world, including Pakistan. The role of root-knot nematode in Pakistan is discussed here together with other aspects of the disease. A historical review of root-knot nematode is given along with details of damage, distribution of the disease and its management.

Motha *et al.*, (2010) conducted a study to investigate the effectiveness of *Pseudomonas fluorescens* and *Trichoderma viride* and two botanicals; ground neem seed and tobacco waste dust for the control of Root-Knot Nematodes (RKN) in Tobacco. Suppression of RKN was examined under field condition by estimating root knots and parasitic nematode counts. Seedling density, fresh weight, dry weight, shoot length and root length of tobacco also were measured to evaluate the growth performance. Results indicated that of all bio-preparations, ground neem seed treatment has suppressed the RKN to the best level expressing least number of root-knots and parasitic nematodes. Tobacco waste treatment found to be the se-ond best followed by the treatment with *P. fluorescens*. Although *T. viride* has not controlled the infec-tion, it has significantly improved the
seedling density and vegetative growth. Further experiments should be conducted to
determine the combined effect of these bio-preparations.

Khalil et al.,(2012) to study the impact of the evaluated treatments namely abamectin,
azadirachtin 0.15%, azadirachtin 0.03%, Bacillus subtilis, Pseudomonas fluorescens,
Paecilomyces lilacinus and oxamyl against root-knot nematode (Meloidogyne incognita)
on the tomato plants cv. Super strain B. P. lilacinus was the most effective treatment on
both galls and egg masses achieving 88.23 and 76.94% reduction, respectively. While,less effective treatment was P. fluorescens achieving 57.53% galls reduction.
Azadirachtin 0.03% was the least effective treatment giving 40.37% reduction of egg
masses. The superior treatment that suppressed nematode populations was oxamyl
recording (88.90%) followed by abamectin (78.69%) reduction. Moreover, azadirachtin
0.15% was the least effective treatment which recorded 60.15% reduction. On the other
hand, plants free nematode recorded the highest plant parameters for shoot system length,
fresh shoot weight, dry shoot weight and root system length with values of 24.15, 107.53,
211.59 and 46.17% increase, respectively. Azadirachtin 0.15% was the least effective
treatment on shoot system length and fresh and dry shoot weight. While, oxamyl
recorded the least increase in root system length estimated by 18.47%. B. subtilis
recorded the highest increase in fresh root weight followed by P. fluorescens with value
of 125.75 and 86.57%, consecutively. Vise versa, P. fluorescens was the superior
treatment to increase the dry root weight by 68.14% followed by B. subtilis which
recorded 35.40%. The least effective treatment in improving fresh root weight was
azadirachtin 0.15% which recorded 54.85% increase. Regarding to dry shoot weight P.
lilacinus and azadirachtin 0.15% were the least effective treatments with values of 8.85
and 2.66% reduction, respectively.

Rao and Krisnappa (1995) to study the effect of soil solarization for the control of
Meloidogyne incognita and Fusarium oxysporum f.sp.ciceri complex pathogenic to
chickpea. Solarization by covering the soil with clear transparent polythene sheet for 6
weeks during hot summer months showed an increase in soil temperature (8c) and
conservation of moisture (5%) when compared to unsolarized control. Increased soil
temperature coupled with soil moisture resulted in a significant reduction in population
densities of \textit{M. incognita} (58.1\%). \textit{Fusarium oxysporum} f.sp.\textit{ciceri} (80.8\%), weeds (80.6\%) and their weight (90.5\%). The availability of soil nutrient were increased by soil solarization. While the physical and chemical characteristics of soil remained unchanged.

Ali and Gurha (1995) studied the effect of \textit{Meloidogyne incognita} infestation on incidence of wilt and root-knot index in chickpea. The highest wilt incidence (80 and 60\% in susceptible and resistant varieties respectively) was found when the plants were inoculated first with nematode and then with \textit{Fusarium oxysporum} f.sp. \textit{ciceri}. With the fungus first followed by the nematode it was 70 and 30\% respectively. \textit{Fusarium} inoculation alone caused 40\% wilt incidence susceptible variety and none in resistant variety of chickpea.

Rao and Krisnappa (1995) the effect of soil solarization for the control of \textit{Meloidogyne incognita} and \textit{Fusarium oxysporum} f.sp.\textit{ciceri} complex pathogenic to chickpea. Solarization by covering the soil with clear transparent polythene sheet for 6 weeks during hot summer months showed an increase in soil temperature (8\degree C) and conservation of moisture (5\%) when compared to unsolarized control. Increased soil temperature coupled with soil moisture resulted in a significant reduction in population densities of \textit{M. incognita} (58.1\%). \textit{Fusarium oxysporum} f.sp.\textit{ciceri} (80.8\%), weeds (80.6\%) and their weight (90.5\%). The availability of soil nutrient was increased by soil solarization. While the physical and chemical characteristics of soil remained unchanged.

Rao and Krishnappa (1996) reported that the density and frequency of occurrence of \textit{Meloidogyne} and \textit{Fusarium} associated with chickpea in Karnataka were found to be influenced by various ecological factors, viz., agro climatic zones, soil type, type of arming, growth stage of the crop cultivar, and previous crop grown. The population of \textit{Meloidogyne} was maximum in the eastern dry zone, in red soil, under irrigated condition, during flowering stage, in cultivar local and Annigeri-1 with ragi and sunflower as previous crops while minimum population was observed in North eastern dry zone, under rainfed conditions during vegetative stage, and no population in clay, sandy loam and murrum soils, in cultivar, Vishwas, Chaffa, and Bhima with paddy, wheat, soybean castor potato, and cotton as previous crop. Similarly, maximum population of \textit{Fusarium} was
observed in North eastern dry zone, in deep black soils, under rainfed condition, during flowering stage in cultivars Chaffa and Annigeri -1 with redgram, cucumber, and chickpea as previous crops, while minimum population was recorded in eastern dry zone, under raifned conditions, during vegetative stage, in cultivar Bhima, and no population in clay and murram soil with paddy, wheat, castor and cotton as previous crops.

Rao and Krishnappa (1996) to investigate the interaction of \textit{Fusarium oxysporum} f.sp.\textit{ciceri} with \textit{Meloidogyne incognita} on chickpea cv.Annegiri in two soil types, viz, alfisol and vertisol. The results indicated that inoculation of fungus either along with nematode or seven days before or after the nematode inoculation resulted in significant reduction in fresh and dry weight of shoot and fresh root of weight as well as increase in the wilt incidence compared to plant inoculated with the fungus alone .Nematode multiplication was high in alfisol and that of the fungus in the vertisol resulting in a high root-knot in the former and more wilt incidence in the latter.

Perveen et al.,(1998) reported that \textit{Pseudomonas aeruginosa} and \textit{Paecilomyces lilacinus} used alone or together significantly (P<0.05)reduced infection of \textit{Meloidogyne javanica} root knot nematode and root infecting fungi viz., \textit{Macrophomina phaseolina},\textit{Rhizoctonia}, \textit{Fusarium solani} and \textit{F.oxysporum} on pumpkin (\textit{Cucurbita pepo}), guar (\textit{Cyamopsis tetragonoloba}), chilli (\textit{Capsicum annum}) and watermelon (\textit{Citrullus lanatus}),\textit{P.aeruginosa} was more effective than \textit{P.lilacinus} in reducing the \textit{M.javanica} root knot nematode infection. Combined use of \textit{P.lilacinus} and \textit{P.aeruginosa} was more effective in reducing the infection of root knot nematode in guar, \textit{M.phaseolina} and \textit{F.oxysporum} on pumpkin and \textit{F.solani} on guar and watermelon than either used alone.

Siddiqui and Haque (2000) reported the potential of two \textit{Pseudomonas aeruginosa} (Pa-7 and IE-6) as biological control agents against \textit{Meloidogyne javanica} at five inoculum densities (0,500,1000,2000 and 4000 juveniles/plant) was tested on tomato in earthen pots.The effects of root-knot nematodes and the root infecting fungi \textit{Fusarium oxysporum}, \textit{F.solani} and \textit{Rhizoctonia solani} on bacterial endphytic colonization (root and shoot) as well as the effect of the bacteria on nematode multiplication, control of the root rot-root knot disease complex and the growth of tomato plants were investigated.
The two *P. aeruginosa* isolates significantly reduced nematode populations and root invasion by the nematode and colonization by the root infecting fungi on tomato. Both the isolates showed similar results at low nematodes densities (500 and 1000 J²) but isolate IE-6 was also effective at the higher nematode densities (2000 and 4000 J²). Bacteria survived well both in roots and stem but increased nematode densities were associated with decreased bacterial populations. A negative correlation between *F. oxysporum* infection and bacterial root and shoot colonization was also observed. A progressive decrease in plant growth was observed with an increase in nematode densities both in bacteria treated and untreated plants but damage caused by *M. javanica* was less in treated plants.

Haseeb *et al.*, (2005) conducted studies under pot conditions to determine the comparative efficacy of carbofuran at 1 mg a.i./kg soil, bavistin at 1 mg a.i./kg soil, neem (*Azadirachta indica*) seed powder at 50 mg/kg soil, green mould (*Trichoderma harzianum*) at 50.0 ml/kg soil, rhizobacteria (*Pseudomonas fluorescens*) at 50.0 ml/kg soil against root-knot nematode, *Meloidogyne incognita*—wilt fungus, *Fusarium oxysporum* disease complex on green gram, *Vigna radiata* cv ML-1108. All the treatments significantly improved the growth of the plants as compared to untreated inoculated plants.

Nagdi & Khair (2008) reported that Eggplant (*Solanum melongena*) is an important vegetable crop; it is infected by root-knot (*Meloidogyne incognita*) and root-rot (*Rhizoctona solani*) pathogens in Egypt. *Bacillus subtilis*, *Pseudomonas fluorescens*, *Trichoderma harzianum* and *Trichoderma viride* were tested for managing these two pathogens in vitro and in the greenhouse in comparison with the nematicide oxamyl. The efficacy of the commercial product Micronema was assessed in the field. *In vitro*, culture filtrates of *B. subtilis*, *P. fluorescens*, *T. harzianum* and *T. viride* at 10% concentration caused nematode mortalities of 100, 99, 98 and 96%, respectively, after 72 hours exposure to the filtrate. Also, *T. harzianum* greatly reduced mycelial growth of *R. solani*, followed by *T. viride*, *B. subtilis* and *P. fluorescens*. 

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Tariq et al., (2009) reported that Chili (*Capsicum annuum*) is an important vegetable and spice crop worldwide produced and consumed as fresh or processed. However production is increasingly constrained by chili plant diseases. The four diseases that lead to wilting in chili are *Phytophthora* root rot, *Verticillium* wilt, *Rhizoctonia* root rot, and *Fusarium* wilt. The association of *Fusarium* species with *Rhizoctonia solani* or root knot nematodes (*Meloidogyne* spp.) caused huge losses. They isolated seven strains of *Pseudomonas aeruginosa* from inner roots of healthy chili plants growing under field condition. In vitro test cell free culture filtrate of some strains showed nematicidal activity against *Meloidogyne javanica* root knot nematode by killing the 2nd stage juveniles and by retarding the egg hatching. In dual culture plate assay, one strain of *P. aeruginosa* inhibited the radial growth of all the four test root rotting fungi *Macrophomina phaseolina*, *Rhizoctonia solani*, *Fusarium solani* and *F. oxysporum* by producing the zone of inhibition. While other strains caused growth inhibition of at least 2 or 3 test fungi. Some bacterial strains also caused lysis of fungal hyphae. In screen house, application of some of these bacterial strains caused significant suppressive effect on root rotting fungi and root knot nematode infecting chili roots. Some *Pseudomonas aeruginosa* strains also showed positive impact on plant growth by increasing the plant height and fresh shoot weight and were found to produce indole-acetic acid at varying degree

Kumar et al., (2009) studies were undertaken to determine the effect of bio-control agents *viz.*, *Aspergillus niger*, *Trichoderma harzianum*, *Paecilomyces lilacinus*, and *Pseudomonas fluorescens* alone @ 100 kg/ha each having $10^8$ cfu/g culture, pesticides *viz.*, carbofuran and bavistin @ 2 kg a.i./ha each and organic amendment *viz.*, neem seed powder @ 500 kg/ha alone and in combination ( @ half dose of each treatment material against root-knot-wilt disease complex caused by *Meloidogyne incognita* and *Fusarium solani* on brinjal. Results indicated that all the treatments alone and in combination significantly improved the number and fresh weight of the seedlings and reduced the root-knot index and % root infection. Carbofuran + *T. harzianum* was found highly effective in increasing the number and fresh weight of seedlings/bed. maximum reduction in root-knot index was also observed in carbofuran + *T. harzianum* treated seedlings.
However, minimum % root infection by *F. solani* was observed in carbofuran + bavistin treated seedlings.

Sivakumar (2009) observed comparative efficacy of four bio-agents viz., *Trichoderma viride*, *Paecilomyces lilacinus*, *Pochonia chlamydosporia* and *Pseudomonas fluorescens* were tested against reniform nematode, *Rotylenchulus reniformis* - *Macrophomina phaseolina* root rot complex on cotton cv. CU-5 during 2006–2007. The bio-agents were effective both as seed treatment and soil application. *P. fluorescens* as seed treatment @ 20 g/ha followed by soil application @ 2.5 kg/ha² was found significantly superior over other treatments recording 62.5% reduction of female nematodes in the root system, 56.4 and 45.6% increase in plant height and root weight, 56.6% reduction in soil population of nematodes and 98.5% increased yield. Seed treatment with *T. viride* was most effective in reducing the root rot incidence to the tune of 91.9% and was on par with *P. fluorescece* in respect of yield.

Hadar et al., (1983) reported that some soils with low iron levels are suppressive to *Trichoderma* spp. because of the activity of *pseudomonads* and their siderophores. Isolates of *Trichoderma* were obtained from a soil suppressive to these fungi. The abilities of these isolates to protect pea seeds against *Pythium* spp. were determined. The two most effective isolates were identified as *T. koningii* and *T. harzianum*. Both isolates grew well on seeds, and neither was affected by seed-colonizing *pseudomonads*. The optimal pH for both isolates was 4.5, and both grew slowly at pH 2 and 8. Both isolates were inhibited by the partially-purified fluorescent pigment from a *Pseudomonas* sp., Both isolates protected seeds against seed rot in soils naturally infested with pythium spp. When applied either as a seed coating in a various adhesives or when applied in gels used for fluid seed drilling. Polyvinyl alcohol tended to give less disease than other adhesives tested. Among gels, Poly Surf (a hydroxyethyl cellulose) and polytran A (a glucan) gave better results than the silica-based Laponite 508. In field trials, *T.Konongii* consistently protected peas and beans against seed rots.
Yasuda and Katoh (1987) isolated 21 strains of fluorescent pigment producing *Pseudomonas* (FPP, *Pseudomonas*) spp. From soil and roots of apple and peach trees using selective media. FPP *Pseudomoans* strains were identified as *Pseudomonas fluorescens* on the basis of the utilization of several organic compounds. All the strains isolated from the roots exhibited antifungal activity.

Ravichandra *et al.*, (1990) reported that a few popular cultivars and promising lines of brinjal were evaluated for their reaction to the two species of root-knot nematode, *Meloidogyne javanica* and the three races of *M.incognita* with the wilt bacterium, *Pseudomonas solanacearum* individually and in various combinations. A local brinjal cultivar ‘Gulla’ showed high degree of resistance to race 1 and 2 of *M.incognita* as well as *P.solanacearum* when inoculated alone. However, other brinjal lines were susceptible to all the four populations of the nematode and also to the bacterium.

Khanna *et al.*, (1990) reported that a study of the tuffeau based French casing mixtures indicated that *Fluorescent pseudomonads* sometimes represented more than 50 per cent of the total bacterial population belonging to *P. fluorescence* and *P. putida*. Certain isolates having a few characters of both these species were classified as intermediate group, thereby establishing a continuum from *P. fluorescence* to *P. putida*. A further splitting into subgroups A and B of this group was possible. Many isolates caused complete suppression in the appearance of blotch symptoms on whole mushroom caps and blocks when tried in combination with pathogenic *P.tolaasii*. One of these biological antagonists, an isolate of *P.fluorescens* biover I proved quite effective in controlling the blotch incidence on *Aqaricus bisporus* beds.

Laha *et al.*, (1992) A Isolates of *Fluorescent pseudomonads* and were tested for their ability to suppress the root rot and damping of pathogen of cotton, *Rhizoctonia solani*. Forty four per cent of the isolates suppressed the growth of the pathogen very strongly. The disease intensity was reduced from 52.6 per cent (with non-bacterized seeds) to zero (with seeds bacterized with isolate F-13, F-14 and F-11) in pot experiments.

Kumar *et al.*, (1993) Isolates of 12 spp. of *Pseudomonas solanacearum* from different solanaceous hosts were differentiated into biovars following. Hayward’s classification
scheme. All the isolates of *P. solanacerum* from tomato, potato, brinjal and bell pepper were identified as biovars III or a sub-type in biovar III. However, the isolate B6 from chilli which differed considerably from all other isolates was tentatively identified as biovar V. All the isolates utilized each of five test carbohydrates namely, glucose, sucrose, fructose, galactose and glycerol.

Singh and Singh (1996) reported that the effect of some plant growth regulators (MH, IAA, Cytokinin, GA₃ and NAA) was determined for mycelial growth and sclerotium formation of *Sclerotinia sclerotiorum*. Maximum mycelia growth and scleroderma formation were obtained in at 10 ppm IAA. Analysis of linear correlation of pH of culture filtrate with myelial dry weight and number of sclerotia indicated that a specific pH is essential for maximum mycelial growth and sclerotium formation. Multiple correlation coefficient analysis of mycelial dry weight with number of sclerotia (*X₃*), *X₃+1*(*X₄*), sclerotia size (*X₅*), sclerotal dry weight (*X₆*) and pH (*X₇*) revealed that maximum prediction for mycelial growth can be made with *X₃*, *X₅*, *X₆*, *X₇*. However very little prediction is possible with pH as a variable at all the concentrations of all the growth regulators.

Laha *et al.*, (1996) Isolates Sixteen forty eight *fluorescent pseudomonad* from cotton rhizosphere were found to be antagonistic to *sclerotium rolfsii*. The level of pathogen growth suppression was substantially reduced when the medium was supplemented with ferric chloride. The sclerotal viability was reduced when immersed in bacterial suspension or their cell-free culture filtrates. The FP isolates were found to be cyanogenic and their volatile metabolites substantially suppressed the pathogen growth. In greenhouse experiment, the isolates FP-47 was most effective in significantly reducing the disease.

Amara *et al.*, (1996) tested five mutants of *Pseudomonas fluorescens* which are induced by acridine treatment and the original strain for their ability to synthesize plant growth substances and fungal inhibition.

Abdelghafar and Abdelsayed (1997) applied *Pseudomonas fluorescens* and *Pseudomonas putida* or their filtrates which inhibited growth of *Erwinia carotovora*. The severity of
bacterial soft rot in vitro significantly decreased on entire, or slices of potato tubers and daughter tubers, when fluorescent pseudomonads were applied as biocontrol agents. Treatment of potatoes with *Pseudomonas fluorescens* or *Pseudomonas putida* or a mixture of both before planting in soil infested with *Erwinia carotovora* reduced soft rot severity. The population of *Erwinia carotovora* was greatly reduced in the rhizosphere of potato plants when seed pieces of potato were treated with *Pseudomonas fluorescens* or *Pseudomonas putida* or a mixture of both. The number and weight of tubers also increased when potato plants were treated with a mixture of *Pseudomonas putida* and *Pseudomonas fluorescens*.

Krishnamurthy and Gnanamanickam (1998) reported the efficiency of *Pseudomonas putida* PpVI4i in the control of sheath blight disease of rice, both in vitro in vivo. The present study focuses on the development of an effective formulation of the bacterium for increased shelf-life, of the various combination tested, methyl cellulose; talc in the ratio 1:4 was found to maintain the bacterium in a viable state for up to 10 months, affording 60% suppression of sheath blight in the field on par with the fungicide validamycin. Further more, the formulation had no adverse effects on seed germination. The results were consistent when tested by the detached leaf assay in vitro.

Yoav (1998) reported that Six strains of *Azospirillum* belonging to five species of plant growth-promoting bacteria *A. brasilense*, *A. lipoferum*, *A. amazonense*, *A. irakense*, and *A. halopraeferent* did not cause visible disease symptoms on the roots or leaves of tomato, pepper, cotton, and wheat, failed to inhibit seed germination, and did not reduce plant dry weight when seven standard techniques for the inoculation of plant pathogens were used. Similar inoculation conditions with plant pathogens viz. *Pseudomonas syringae* pv. *tomato*, *Xanthomonas campestris* pv. *vesicatoria*, *Xanthomonas campestris* pv. *translucens*, and *Xanthomonas campestris* pv. *malvacearum* induced typical disease symptoms. None of *Azospirillum* strains caused the hypersensitive reaction on eggplant, whereas all pathogens did. All *Azospirillum* strains increased phytoalexin production in all disease-resistant plant species to moderate levels, but the levels were significantly lower than those induced by the compatible pathogens. The various phytoalexins produced in plants had the capacity to inhibit growth of all *Azospirillum* strains.
Anith et al., (1999) reported that *Pseudomonas sp.* strain EM 85, a rhizosphere isolate, showed *in vitro* antifungal activity against a number of soil borne plant pathogens and produced multiple antifungal compounds. A mutant AN 21 generated from the wild type strain by chemical mutagenesis showed no antifungal property. The wild type and the mutant strains were analyzed in detail with respect to the antifungal activity. Both the strains produced similar levels of siderophores, HCN and fluorescent pigments. The mutant however was unable to produce an antifungal antibiotic and failed to inhibit the fungal growth. In *vivo* experiment also established that antifungal antibiotic was responsible for the disease control ability of the strain.

Mondal et al., (1999) reported that Five, out of fortytwo, cotton rhizobacteria (CRb) were selected for intensive studies on the basis of their *in vitro* antagonistic activity towards the most predominant and virulent race-32 of *Xanthomonas axonopodis PV. Malvacearum*, the inducer of bacterial blight of cotton. These five isolates were identified as *Pseudomonas fluorescens* (CRb-26 and CRb-39), *Pseudomonas putida* (CRb-17) and *Pseudomonas alcaligenes* (CRb-9 and CRb-14). Isolates CRb-26 was most effective in inhibiting the growth of Xam. Treatment of seeds with CRb-26 (10^7 cfu/ml) increased the germination of cotton (Acala-44) seeds by 12.82 per cent and improved the development of normal seedlings by 22.58 per cent. Application of CRb-26 on Xam inoculated seeds resulted in maximum improvement in germination with concomitant reduction in cotyledonary infection as compared to other rhizobacterial isolates tested. CRb-26 heavily colonized the cotyledons of cottons and caused drastic reduction in Xam population. Inoculation of CRb -26 to leaves also caused significant reduction in the disease severity.

Manoranjitham et al., (2000) reported the a influence of talc–based formulation of *Trichoderma viride* and *Pseudomonas fluoresncens* on damping-off disease ,growth of chilli seedlings and population of *Pythium aphanidermatum* was studied under pot culture conditions. Seed treatment with *T.viride* (4g.kg ^-1) +*P.fluoresncens* (5kg^-1) showed 7.00 and 12.50 percent pre and post-emergence damping –off, respectively against 27.50 and 54.75 % in control The treatment also increased the shoot length, root length and dry matter production of chilli seedlings and reduced the population of
*P. aphanidermatum* from 16.75x 10^{-2} cfu g^{-1} at the time sowing to 13.4x10^{-2} cfu g^{-1} at 20 days after showing compared to 17.50x10^{-2} cfu 17.08x10^{-2} cfu g^{-1} in control.

Sivakumar *et al.* (2000) observed that *pseudomonas fluorescens* PF-1 isolated from the crop rhizosphere, exhibited inhibitory action against *Rhizoctoma solani* f sp. *Sasakii* Exner, causing banded leaf and sheath blight of maize. Among the carriers, peat and tale were noted to maintain the population at 19.5 x 10^7 and 18.3 x 10^7 cfu per g of the product, respectively after 40 days of storage. The disease was effectively controlled by seed treatment of the peat based formulation @ 16g/kg or as soil application @ 2.5 kg/ ha or y spraying the liquid formulation twice @ 5 g/l of water.

Girlanda *et al.* (2000) reported the effects of *Pseudomonas fluorescens* CHAO-Rif, which produces the 2,4-diacetylphloroglucinol (PhI) and *pyoluteorin* (Plt) and protects cucumber from several fungal *Pythium spp.*, as well as the genetically modified derivative *CHAO-Rif* (pME3424). Strain CHAO-overproduces Phl and Plt and displays improved biocontrol efficiency compared with *CHAO-Rif*, repeatedly in the same soil, which was left uninoculated, and inoculated with *CHAO-Rif* or CHAO. Treated with the fungicide metalaxyl (Ridomil). Treatments was applied to soil at the start of each growth cycle, and their effects on the diversity of the rhizosphere population of culturable fungi of the first and fifth cycles. Over 11,000 colonies were studied and assigned to 105 fungal species (morphotypes). The most frequently isolated fungal species of the genera are *Phialocephala*, *fusarium*, *Gliocladium*, *Penicillium*, *Mortierella*, *Verticillum*, *Trichoderma*, *Coniothyrium*, *Cylindrocarpon*, *Myrothecium* and *Monocillium* were common in the four treatment species was totally suppressed or found exclusively following one particular treatment. However, growth cycles studied, significant differences were found between treatments (e.g., between the cycle treatments and/or between the two inoculation treatments) using discriminant analysis. Despite the composition and/or relative abundance of species in the fungal community, treatments had no effect indices, and species abundance distributions fit the truncated lognormal function in most cases. Treatment at the 32-day mark of either growth cycle was smaller than the effect of growing cucumber same soil.
Sonwane and pawar (2001) studies on antagonism between *Fusarium oxysporum* f.sp.*ciceri* and *Trichoderma viride*, *T. harzianum*, *T. hamatum* and *Aspergillus awamori*, were conducted in vitro by adopting the dual culture technique. *T. harzianum* was very effective in controlling vegetative growth of the pathogen followed by *T. hamatum*. In a related experiment, the integrated management of chickpea wilt was studied by conducting pot culture experiment in a glasshouse. Chickpea seeds were soaked in spore suspension of bioagents for 8 h and were sown in pots with wilt-infected soil. Integrated management treatments comprised: *T. viride*, *T. harzianum*, *T. hamatum*, *Pseudomonas fluorescens*, *Rhizobium*, 1.5 g Benlate T [benomyl + thiram]/kg, 2.5 g Bavistin [carbendazim]/kg, 2.5 g thiram/kg and/or 1% garlic extract. *T. harzianum* was the most effective treatment, followed by Bavistin and garlic extract.

Vishwanathan and Samiyappan (2001) observed that a Strains of *Pseudomonas spp.* native to sugarcane rhizosphere were isolated and tale based formulation was prepared. The efficient bacterial strains KKMI (*P. putida*) and VPT4 (*P. fluorescens*) were found including systemic resistance in sugarcane cultivar CoC 671, susceptible to red rot-disease caused by the fungus *Colletotrichum falcatum*. Sett treatment with bacterial strains induces higher accumulation of chitinase in the germinating settlings. In matured crop, soil application of *pseudomonas sp.* strains induces chitinase activity systemically in sugarcane stalk tissues. Pathogen inoculation in the stalk tissues showed multifold increase in chitinase activity in the *Pseudomonas* treated canes whereas, in the *Pseudomonas* untreated canes the increase was less after pathogen inoculation. Western blot analysis revealed induction of 18 kDa chitinase in the stalk tissues in response to *Pseudomonas* treatment or *C. falcatum* inoculation. However, in the *Pseudomonas* treated canes challenge inoculation of *C. falcatum* revealed induction of four new chitinase isoforms with molecular weight of 12,34.5, 53.5 and 63kDa, whereas the control plants showed none of the chitinases after pathogen inoculation. Induction of new chitinases in the *Pseudomonas* treated sugarcane in response to *C. falcatum* infection indicates that the need induced chitinases have a definite role in suppressing the disease development in the stalk tissues.
Khan and Zaidi (2002) reported that nine strains of *fluorescent pseudomonas* isolated from the rhizospheres of wheat and chickpea were characterized morphologically as well as biochemically for indole acetic acid, siderophores and lipolytic activity. Most strains were capable of IAA synthesis (<20ug/ml). Biosynthesis of IAA was enhanced by increasing the concentrations of tryptophan added to the growing medium. All of the strains produced siderophores but the degree of siderophores production varied from strain to strain. Among the strains, PC-4, PW-7 and PW-9 isolated from chickpea and wheat rhizosphere respectively were found as potential siderophores producers. The culture broth and cell free filtrate of the strains produced lipases in solid medium plates containing tributyrin as indicator. In general, the cell free filtrates of the *Fluorescent pseudomonas* produced more lipases than their respective culture broths and an increase of 0.6 to 26.8% was recorded over culture broth. Further in vitro antagonism against *Botrytis cinerea, Rhizoctonia solani, Fusarium oxysporum, Macrophomina phaseolina, Pythium aphanidermatum* and *Trichoderma viride* by PC-3, PC-4, PW-6, PW-7 and PW-9 was determined. Cell free filtrates of PW-7 and PW-9 showed antagonism activity against *B. cinerea, R. solani, F. oxysporum* and *P. aphanidermatum* growing on PDA.

Ramamoorthy *et al.*, (2002) twenty isolates of fluorescent pseudomonads were evaluated for their ability to control damping-off in tomato (*Lycopersicon esculentum*) and hot pepper (*Capsicum annuum*). These isolates were characterized as *Pseudomonas fluorescens* and *Pseudomonas putida*. Two isolates, PFATR and KKM 1 belonged to *P. putida* and the remaining 18 isolates belonged to *P. fluorescens*. Among these isolates, *P. fluorescens* isolate Pf1 showed the maximum inhibition of mycelial growth of *Pythium aphanidermatum* and increased plant growth promotion in tomato and hot pepper. *P. fluorescens* isolate Pf1 was effective in reducing the damping-off incidence in tomato and hot pepper in greenhouse and field conditions. Isolate Pf1 was further tested for its ability to induce production of defenserelated enzymes and chemicals in plants. Earlier and increased activities of phenylalanine ammonia lyase (PAL), peroxidase (PO) and polyphenol oxidase (PPO) were observed in *P. fluorescens* Pf1 pretreated tomato and hot pepper plants challenged with *Pythium aphanidermatum*. Moreover, higher accumulation of phenolics was noticed in plants pretreated with *P. fluorescens* isolate Pf1 challenged with *Pythium aphanidermatum*. Thus, the present study shows that in addition to direct
antagonism and plant growth-promotion, induction of defense-related enzymes involved in the phenyl propanoid pathway collectively contributed to enhance resistance against invasion of *Pythium* in tomato and hot pepper.

Kumar *et al.*, (2002) reported that Plant growth-promoting rhizobacterial strains belonging to fluorescent *pseudomonads* were isolated from the rhizosphere of rice and sugarcane. Among 40 strains that were confirmed as *Pseudomonas fluorescens*, 18 exhibited strong antifungal activity against *Rhizoctonia bataticola* and *Fusarium oxysporum*, mainly through the production of antifungal metabolites. Genotyping of these *P. fluorescens* strains was made by PCR–RAPD analysis, since differentiation by biochemical methods was limited.

Jetiyanon and Kloepper (2002) confirmed induced systemic resistance using strains of plant growth-promoting rhizobacteria (PGPR) have concentrated on the use of individual PGPR as inducers against multiple diseases of a single crop. Twenty-one combinations of PGPR and seven individual PGPR were tested in the greenhouse for induced resistance activity. Results indicated that four mixtures of PGPR and one individual strain treatment significantly reduced the severity of all four diseases compared to the nonbacterized control: 11 mixtures reduced CMV of cucumber, 16 mixtures reduced bacterial wilt of tomato, 18 mixtures reduced anthracnose of long cayenne pepper, and 7 mixtures reduced damping off of green kuang futsoi. Most mixtures of PGPR provided a greater disease suppression than individual PGPR strains. These results suggest that mixtures of PGPR can elicit induced systemic resistance to fungal, bacterial, and viral diseases in the four hosts tested.

Shanmugam *et al.*, (2003) reported that *Pseudomonas fluorescens* strain Pf 1, effectively inhibited the mycelial growth of *Macrohominia phaseolina*, the pathogen causing dry root rot in groundnut. Application of Pf 1 as seed treatment (10 g/kg seed) followed by soil application (2.5 kg/ha) against root rot, effectively supported higher plant growth, better native nodulation and grain yield. Sclerotial number and root rot incidence were also greatly reduced.
Pande and Chaube (2003) observed that in vitro antibiosis of 6 isolates of *Pseudomonas fluorescens* resulted in reduction of mycelial growth of *Rhizoctonia solani* and the inhibition zone ranged from 1.3 to 22.5 mm in different isolates on Kings-B medium. Similarly 3.3 to 12.0 mm inhibition zone was recorded on PDA. Sclerotial inactivation studies indicated that pre-treatment of bacterial isolates to sclerotia for different lengths of time affected sclerotial viability in vitro. Pre-treatment of sclerotia resulted in 3.3 to 100% inhibition in their germination after these were immersed in bacterial cell suspension of *P. fluorescens* isolates for 1 min. to 4 weeks. In green house study, there was 17.7 to 100% reduction in rice sheath blight infection due to pre-treatment of sclerotia for 4 weeks in suspension of *P. fluorescens* isolates.

Lee *et al.*, (2003) observed the isolated bacterial strain MM-B16, from a mountain forest soil in Korea. Based on the physiological and biochemical characteristics and 16S ribosomal DNA sequence analysis, the bacterial strain MM-B16 was identical to *Pseudomonas fluorescens*. An antibiotic active against *Colletotrichum orbiculare* and *Phytophthora capsici* in vitro and in vivo was isolated from the culture filtrates of *P. fluorescens* strain MM-B16 using various chromatographic procedures. The molecular formula of the antibiotic was deduced to be C10H11NO2S (M+, m/z 209.0513) by analysis of electron impact mass spectral data. Based on the nuclear magnetic resonance and infrared spectral data, the antibiotic was confirmed to have the structure of a thiazoline derivative, aerugine [4-hydroxymethyl-2-(2-hydroxyphenyl)-2-thiazoline]. *C. orbiculare*, *P. capsici*, and *Pythium ultimum* were most sensitive to aerugine (MICs for these organisms were approximately 10 _μg ml_−1). However, no antimicrobial activity was found against yeasts and bacteria even at concentrations of more than 100 _μg ml_−1. Treatment with aerugine exhibited a significantly high protective activity against development of phytophthora disease on pepper and anthracnose on cucumber. However, the control efficacy of aerugine against the diseases was in general somewhat less than that of the commercial fungicides metalaxyl and chlorothalonil. This is the first study to isolate aerugine from *P. fluorescens* and demonstrate its in vitro and in vivo antifungal and antioomycete activities against *C. orbiculare* and *P. capsici*.
Vaidya et al., (2004) isolated from the rhizosphere soils *Pseudomonas fluorescens*, *streptomyces* spp. and *Trichoderma* spp., of various crops, were screened by dual culture and cell free culture filtrate technique against *Fusarium oxysporum* f.sp. dianthi and *F. oxysporum* f.sp. gladiolus causing wilt in carnation and gladiolus, respectively. Several isolates effectively inhibited mycelial growth of *Fusarium* in vitro. *Pseudomonas, streptomyces* and *Trichoderma* exhibited considerable difference in their antagonism against *Fusarium*. The antagonistic efficacy of various isolates also differed markedly within *Pseudomonas, Streptomyces* and *Trichoderma* and their effect on the pathogen isolates from carnation and gladiolus. Among *P. fluorescens* isolates, PAPF –Nagrota exerted the maximum inhibition against *F. o.f.sp. gladioli*. *Streptomyces* isolate CAAC-Banuri exerted the maximum inhibition against *F.o.f.sp.gladioli*. Among the isolates of *Trichoderma*, CATR-Darang and GLTR-Chauntra were equally effective against *F.o.f.sp. dianthi*, while GLTR-Kotli was effective against *F.o.f.sp. gladioli*. Similar trend of inhibition obtained in dual culture and cell free culture filtrate assay indicated the involvement of secondary metabolites in antagonism by the biological control agents. The antagonistic effects were elucidated in terms of antibiotic equivalence in respect of fluconazole and carbendazim for the isolates exhibiting high antagonistic potential.

Kloepper et al., (2004) observed that the PGPR (plant growth-promoting rhizobacteria) are root-colonizing bacteria that benefit plants by increasing plant growth or reducing disease. Current applications of PGPR as biocontrol agents rely on mixtures of PGPR as components in integrated management systems in which reduced rates of agrochemicals and cultural control practices are used. The finding that some strains of PGPR can elicit systemic disease protection has renewed interest in PGPR for practical application in Agriculture and horticulture. We report here results of attempts to combine PGPR with different modes of action with organic amendments. Our hypothesis was that such an integrated system could be used for transplanted vegetables to produce more vigorous transplants that would be tolerant of nematodes and other diseases for at least a few weeks after transplanting to the field. The specific combination that we tested consisted of *Bacillus subtilis* strain GB03, *B. amyloliquefaciens* strain IN937a, and *B. subtilis* strain IN937b together with chitosan. Strain GB03 produces antibiotics while IN937a and IN937b elicit induced systemic resistance. Chitosan was added to stimulate a microflora
antagonistic to nematodes. Results demonstrated that the combination of two bacilli strains with chitosan resulted in significant growth promotion that was correlated with induced resistance in tomato (Lycopersicon esculentum), bell pepper (Capsicum annuum), cucumber (Cucumis sativus) and tobacco (Nicotiana tabacum). The preparation has been commercialized by Gustafson, LLC under the name “BioYield” and is discussed as a model for extending PGPR technologies to growers. BioYield is incorporated into the potting mix used to prepare transplants. Treated transplants demonstrate increased shoot and root growth, enhanced stem diameter, less transplant shock, and rapid development of new roots. Disease protection is sometimes observed, but the most reproducible effect is growth promotion resulting in yield increases with many tested transplant systems.

Khalid et al., (2004) Isolates thirty prolific growth on agar medium were selected and evaluated for their potential to produce auxins in vitro. Colorimetric analysis showed variable amount of auxin (ranging from 1.1 to 12.1 mg 1-1) produced by the rhizobacteria in vitro and amendment of the culture media with 1-tryptophan (1-TRP), further stimulated auxin biosynthesis (ranging from 1.8 to 24.8 mg 1-1). HPLC analysis confirmed the presence of indole acetic acid (IAA) and indole acetamide (IAM) as the major auxins in the culture filtrates of these rhizobacteria. A series of laboratory experiments conducted on two cv. Of wheat under gnotobiotic (axenic) conditions demonstrated increases in root elongation (up to 17.3%), root dry weight (up to 13.5%), shoot elongation (up tp 37.7%) and shoot dry weight (up to 36.3%) of inoculated wheat seedlings. Linear positive correlation (r=0.99) between in vitro auxin production and increase in growth parameters of inoculated seeds was found. Based upon auxin biosynthesis and growth-promoting activity, four isolates were selected and designated as plant growth-promoting rhizobacteria (PGPR). Auxin biosynthesis in sterilized vs nonsterilized soil inoculated with selected PGPR was also monitored that revealed superiority of the selected PGPR over indigenous microflora. Peat-based seed inoculation with selected PGPR isolates exhibited stimulatory effects on grain yield experiments (up to 27.5% increase over control and field experiments (up to 27.4% increase over control); however the response varied with cv. and PGPR strains.
Antoun and Prevost (2005) studied that the term PGPR which underlines the need to have a uniform definition to be used by all authors. The actual biodiversity of PGPR will be illustrated by examples of genera and species chosen from the literature and their mechanisms of action for the following different groups: *diazotrophs, bacilli, pseudomonads* and *rhizobia*. As PGPR are introduced in an ecosystem where intense interactions are taking place, we describe how plants, mycorrhiza, and soil fauna can influence the microbial diversity in the rhizosphere. Finally, the beneficial interactions between PGPR and symbiotic microorganisms in the *Rhizobium*-legume symbiosis, and in mycorrhizal plants are discussed. Interactions of PGPR with protozoa and nematodes are also examined.

Utkhede and Mathur (2005) to evaluate biologicals and chemicals for control of internal fruit rot of peppers caused by *Fusarium subglutinans* under greenhouse conditions. *Fusarium subglutinans* inoculum was pipetted on flowers of sweet peppers cv. Sympathy one day after applications of chemical and biological treatments. Pepper fruits were assessed for disease incidence and fruit weight sixty days after inoculation of flowers. Pepper fruits in PreStop®, Rovral®, BASF-516 and Quadra-137 treatments were significantly less infected than those observed in inoculated control treatment for 3 inoculations dates in both years. Treatments with Mycostop® and PlantShield® showed significantly less infected fruits compared with the control on 2 inoculations dates in both years. Flowers treated with Rovral® had significantly higher fruit weight compared with the control on 4 inoculation dates in 2003 and for 3 inoculation dates in 2004. Treatments with PreStop® and Quadra-137 produced heavier fruit than the control treatment for 3 inoculation dates in both years. Further suggest that chemical and biological treatments have the potential to prevent internal fruit rot caused by *F. subglutinans* on peppers under greenhouse conditions.

Pawar *et al.*, (2005) Investigated during the year 1998-99 with a view to study the seed borne fungi of chilli and the effect of fungicidal seed treatment on seed mycoflora, seed quality, storability, seedling health, vigour and seedling mortality in 3 important cultivar Phule Jyoti. Sankeshwari. Fungi isolated by following different methods were *Fusarium moniliforme, Colletotrichum capsici, Aspergillus niger, Alternaria sp. and Curularia*
lunata. Thiram (0.15%) + Carbendazim (0.5%) and Thiram (0.3%) brought maximum inhibition of pathogen in Phule Jyoti, shankeshwari and local chilli cultivars as compared to carbendazim (0.3%), Aureofungin (0.3%) and untreated control. All the fungicides improved seed germination and reduced mortality of seedlings in all the cultivars than untreated control. All the fungicides improved seed germination and reduced mortality of seedlings in all the cultivars than untreated control. Storability studies indicated significant reduction in germination percentage, vigour index and increase in seed mycoflora after 180 days storage period in Phule Jyoti, Shankeshwari and local cultivars in all the methods. Dry seed treatment with thiram (0.15%) + carbendazim (0.5%) and thiram (0.3%) considerably increased the germination percentage, vigour index and reduced seed mycoflora in all the cultivars as compared to other treatments and untreated control.

Siddiqui (2006) studied about plant growth promoting rhizobacteria (PGPR) as indigenous to soil and the plant rhizosphere and plays a major role in the bio control of plant pathogens. They can suppress a broad spectrum of bacterial, fungal and nematode diseases. Progress is made for their diversity, colonizing ability, mechanisms of action, formation and application which facilitate their development as reliable bio control agents against plant pathogens. Greater application of PGPR is possible in agriculture for bio control of plant pathogens and bio fertilization.

Ganeshan & Kumar (2006) reported that *Fluorescent Pseudomonads* belong to plant Growth Promoting Rhizobacteria (PGPR), the important group of bacteria that play a major role in the plant growth promotion, induced systemic resistance, biological control of pathogens etc. The efficacy of bacterial antagonists in controlling fungal diseases was often better as alone, and sometimes in combination with fungicides. The present review refers to occurrence, distribution, mechanism, growth requirements of *P. fluorescens* and diseases controlled by the bacterial antagonist in different agricultural and horticultural crops were discussed.

Saikia et al., (2006) Isolates three strains of *Pseudomonas aeruginosa* were used for seed treatment of rice; all showed plant growth promoting activity and induced systemic
resistance in rice against *Rhizoctonia solani* G5 and increased seed yield. Production of salicylic acid (Sal) by *P. aeruginosa* both in vitro and in vivo was quantified with high performance liquid chromatography. All three isolates produced more Sal in king’s B broth than in induced roots. Using a split root system, more Sal accumulated in root tissues of bacterized site than in distant roots on the opposite site of the root system after 1 d, but this difference decreased after 3d. Sal concentration 0-200 g/L showed no inhibition of mycelial growth of *R. solani* in vitro, while at >_300 g/L it inhibited it. *P. aeruginosa* pretreated rice plants challenged inoculation with *R. solani* (as pathogen), an additional rice plants were detected; molar mass of these purified peroxidases was 28,36 and 47 kDa. Purified peroxidases showed antifungal activity against phytopathogenic fungi *R. Solani, pyricularia oryzae* and *Helminthosporium oryzae*.

Rini and Sulochana (2006) Isolated *Trichoderma* (*T. harzianum* TR20 and *T. pseudokoningii* TR17) and *fluorescent pseudomonas*(*pseudomonas fluorescens* P28 and P51) were evaluated (alone and combination) under green house and field conditions for efficacy in suppressing *Rhizoctonia* root rot incidence and promoting plant growth in chilli. The combination, *T harzianum* (TR20)+*P. fluorescens* (P28), was most effective in reducing disease incidence (66.7%) more efficient than the control, but was at par with copper oxychloride (0.3%). Highest per plant yield also recorded in the treatment combination TR20+P28, followed by *T. pseudokoningii* (TR17)+*P. fluorescens*(P51), *T. pseudokoningii* (TR17) and *T. harziznum* (TR20) when applied alone also significantly increased the yield per plant and was superior to both the pseudomonads applied individually.

Jayasinghearachchi and Seneviratne (2006) reported *Mycelial colonization and biofilm formation* with *Pleurotus ostreatus* a mushroom fungus and its effect on the endophytic colonization of tomato by *Pseudomonas fluorescens* when the plant growth medium was treated with co-culture of *P. fluorescens* and *P. ostreatus*, was investigated aseptically under in vitro conditions. *Mycelial colonization* by *P. fluorescens* started one day after co-culturing them in a broth culture. The bacteria colonized heavily on mycelial surface of *P.ostreatus* forming biofilms after 4 days of co-culturing. Endophytic populations of *P.fluorescens* in leaves, shoots and roots of the plant were higher when the plant growth
medium was treated with biofilmed inoculum than an inoculums with planktonic (freely swimming) bacterial cells (i.e., without the fungus), after 21 days of planting. Plant growth was not affected by *P. ostreatus*.

Anjum *et al.*, (2007) observed that the effect of PGPR inoculation alone and in combination with three levels of mineral nitrogen fertilizer (0-56-60, 56-56-60 and 112-56-60 kg NPK/ha) on cotton (cv. MNH-552). The bacterial inoculums (50 g / kg of seed) significantly increased seed cotton yield (21%), plant height (5%) and microbial population in soil (41 %) over their respective controls while boll weight GOT and staple length remained statistically unaffected.

Kumar *et al.*, (2007) Isolates *Pseudomonas fluorescens* was tested for the induction of systemic resistance against dry root rot of chickpea caused by *Macrohomina phaseolina*. Among five isolates of *P. fluorescens*, Pf4-99 was strong siderophore producing and plant growth promoter. This isolate also inhibited the mycelial growth of *M. phaseolina* in in vitro and decreased the root rot incidence under polyhouse. In Pf4-99 treated plants, an increase in phenolic content was observed on 5*th* d while maximum increase in Pal activity was observed on 4*th* d after challenge inoculation with *M. phaseolina*. A marked increase in Chitnase and B-1, 3 glucanase activity was observed in response to pathogen inoculation in Pf4-99 treated plants. An increase in PPo activity was observed upon challenge inoculation with pathogen. The fluorescens isolate pf4-99 systematically induced resistance against dry root rot of chickpea by the cumulation of battery of enzyme in response to pathogen infection.

Sharma (2007) developed an efficient micropropagation protocol for *Capsicum annuum* L. cv. ‘Morok Amuba’, an ornamental chilli cultivar using shoo-tip and axillary shoot-tip explants. Multiple shoot buds were induced from shoot-tip explants on MS medium containing cytokinins alone or in combination with IAA. A maximum number of shoot buds was induced on MS medium containing 10 mg/l Zea followed by 5 mg/l BAP in combination with 1 mg/l IAA. Rooting and elongation of the shoot buds were achieved on MS medium supplemented with 0.5 mg/l IAA or IBA. Axillary shoots were induced on the rooted plantlets by decapitation and the axillary shoot-tips explants were used for
further induction of shoot buds by culturing them on a medium containing combinations of BAP with IAA. The shoot buds were rooted on a medium containing 0.5 mg/l IBA. The plantlets showed 80-90% survival during transplantation.

Srivastava and Shalini (2008) reported that an antifungal activity of different strains of *Pseudomonas fluorescens* were tested against some plant pathogens such as *Alternaria cajani*, *Curvularia lunata*, *Fusarium sp*, *Bipolaris sp* and *Helminthosporium sp*. in vitro. Different concentrations (1000, 2000, 3000, 4000 and 5000 ug/mL) of *Pseudomonas fluorescens* were used and maximum spore germination of fungus was inhibited at 4000 and 5000 ug/mL. The result indicated that all the strains of *Pseudomonas fluorescens* presented a most significant value against *Alternaria cajani* and *Curvularia lunata*. Out of the five strains studied, the best result was shown by A-5, which showed almost complete inhibition against pathogenic fungi such as *Curvularia lunata* and *Fusarium sp*. at 4000 and 5000 ug/mL while strain L-5 was resistant against *Fusarium sp.* and *Helminthosporium sp.* at 5000 ug/mL. Among the fungus tested, bacterial strains C-03 and Pf4-1 were found to be more sensitive to *Fusarium sp.* and *Helminthosporium sp.*

Rani et al., (2009) reported that the performance of six *Trichoderma* and four *Pseudomonas* isolates were evaluated for bio-control efficacy ability to induce systemic resistance against *Fusarium solani* causing wilt of chilli which is posing a serious threat to chilli cultivation in the irrigated tracts of black cotton soil in India. Among six *Trichoderma* isolates, maximum inhibition was noticed in *T.viride* (indigenous) followed by *T. viride* -16 and *T. harzianum* -10. Among four bacterial bio-agents, an indigenous isolate of *Pseudomonas fluorescens* (Pfi) was most efficient with 74.26% inhibition followed by *P. fluorescens*-PGPR isolate. The bio-agents when coated on seeds of popular chilli cultivars, *T. viride* -16 and *T. viride* (indigenous_ isolates were best in terms of inhibition with out affecting germination of seeds. In case of bacterial bio-agents, the inhibition was above 68.89% on chilli cultivars Byadagi Kaddi by Pf-1. Efficient bio-agents when treated on seeds, *T.viride* reduced the propagules of the pathogen from 10.32*10^6 cfu g^-1 of soil to 1.4*10^6 cfu g^-1 of soil followed by *T.viride* 16. The pf-1 showed highest induction of systemic resistance on chilli plants with increased seed germination and vigour index when challenge inoculated with *F.solani*.
Raj and Christopher (2009) reported that four cultivars of chilli infected by *Colletotrichum capsici* were treated with bio-control agents and fungicides. *Pseudomonas fluorescens* and *Trichoderma harzianum* pure cultures $1 \times 10^8$ cfu g$^{-1}$ and their talcum based formulations ($28 \times 10^7$ cfu g$^{-1}$ & $19 \times 10^7$ cfu g$^{-1}$) 5 g kg$^{-1}$ and 10 g kg$^{-1}$ of seeds were used, respectively. The treated seeds were evaluated for % reduction of *C. capsici*, seed germination and vigour index. It was found that the pure culture of *P. fluorescens* was most effective in reducing *C. capsici* infection followed by *T. harzianum* than the fungicides treated and untreated seeds. Formulations of *P. fluorescens* were also effective in increasing the seed germination.

Tiwari and Thrimurty (2009) Isolates seven of *Pseudomonas fluorescens* from Chhattisgarh region and were confirmed on the morphological and biochemical basis and screened by dual culture method for their antagonistic ability against *Magnaporthe grisea* and *Rhizoctonia solani*. All the isolates were significantly inhibited the growth of the test fungi. Maximum inhibition (76.3%) was recorded with the isolate pfr2 against *M. grisea* whereas in case of *R. solani* maximum inhibition (75.2%) was recorded with isolate pfr1. Efficacy of *P. fluorescens* isolate pfr1 was evaluated for their plant growth promotion and disease management ability in rice. Under mist chamber and field conditions, *P. fluorescens* isolate pfr1 promoted the shoot length and number of tillers in rice and also effectively reduced the blast and sheath blight severity when applied as seedling treatment with one or two foliar sprays.

Singh and Sinha (2009) reported the influence of soil pH, zinc and organic amendments on *Pseudomonas fluorescens* and sheath blight of rice in nursery and under glasshouse conditions were evaluated. Incidence of sheath blight was higher (45.01%) in acidic soil (5.2) as compared to neutral soil i.e. 7.0 (40.42%) or alkaline soil i.e. pH 8.3 (37.43%). Effectiveness of *Pfr* 1 on sheath blight was higher in neutral soil than in acidic or alkaline soil. Soil application of *Pfr* 1 in zinc amended soil or with out zinc application showed 15.96% and 20.36% disease severity, respectively. Soil without zinc and bioagent applications resulted in 45.63% sheath blight severity. Soil incorporation of neem cake enhanced the effectively of the bioagent in increasing seedling emergence (66.60%) and reducing sheath blight severity (65.89%) and disease incidence (77.15%) as compared to
the control. Application of farm yard manure + \( Pfr \) 1 or dhiancha (sesbania eculeata) + \( Pfr \) 1 in soil resulted in 59.25% and 57.51% reduction in disease severity.

Choudhary et al., (2009) reported that environmental concerns have led to the need of sustainable use of natural resources. Plants constitute an excellent ecosystem for microorganisms that interact with plant tissues and cells with differing degrees of dependence. Studies on the relationship between roots and microbiota are essential to achieve viable agricultural applications. Plant growth-promoting rhizobacteria are employed as inoculants for biofertilization, phytostimulation and biocontrol. Various bacterial strains, in particular the fluorescent \textit{Pseudomonas} spp., play an important role in the prevention of plant infectious diseases. Plant-associated pseudomonads live as saprophytes and parasites on the plant surface and inside plant tissues. Many of them promote plant growth by suppressing pathogenic microorganisms, synthesizing growth-stimulating plant hormones and promoting increased plant disease resistance. New biotechnological products are currently being developed based on stimulation of the plant defence response and on the use of plant-beneficial bacteria for biological control of plant diseases (biopesticides) and for plant growth promotion (biofertilizers). This review summarizes and discusses various studies of fluorescent pseudomonads from the plant rhizosphere, and shows that their use is a worthwhile approach for exploring disease management in conjunction with other strategies.

Ekefan et al., (2009) four isolates of \textit{T. harzianum} (Th-F, Th-G, Th-I and Th-N) obtained from CABI Biosciences, Egham, UK were evaluated. \textit{In-vitro} interactions between \textit{C. capsici} and \textit{T. harzianum} isolates showed that \textit{T. harzianum} isolates significantly (\( P \leq 0.05 \)) reduced colony radius of \textit{C. capsici} compared to the control. Seed treatment with \textit{T. harzianum} isolates compared to benomyl showed that incidence of \textit{C. capsici} was significantly (\( P \leq 0.05 \)) lower with benomyl followed by Th-G treated seeds than with the other treatments. Effect on radial growth and sporulation of \textit{C. capsici} was highest (\( P \leq 0.05 \)) when the seeds were treated with Th-G followed by Th-I, benomyl and Th-F. Percent germination was significantly (\( P \leq 0.05 \)) higher in control followed by benomyl treated seeds compared to other treatments. Seed treatment with Th- F, Th-G and Th-I resulted in significantly (\( P \leq 0.05 \)) lower percent dead seedlings compared to seeds
inoculated with *C. capsici* (CAF2) alone. Seeds treated with Th-N had significantly higher seedling length compared to the seeds treated with CAF2 alone. All the *T. harzianum* isolates tested against soil borne *C. capsici* significantly (*P*≤0.05) reduced colony forming units of the pathogen during the first week but subsequently, there was no significant difference. The *Trichoderma harzianum* isolates tested suppressed the growth of *C. capsici* and reduced the incidence of the pathogen on seeds and soil.

Muthulakshmi *et al.*, (2010) conducted field experiments for the evaluation of efficacy of biocontrol agents *viz.*, *Pseudomonas fluorescens* and *Trichoderma viride*, against root-knot nematode, *Meloidogyne incognita* in mulberry (V1 variety), revealed that soil application of both *P. fluorescens* and *T. viride* alone or in combination was able to control the nematode population and improve the mulberry leaf yield and nutritional standards. Combined soil application of *P. fluorescens* (@ 10 g/plant) + *T. viride* (@ 10 g/plant) as soil application was effective to check the root knot nematode disease and to improve growth of mulberry with increased leaf yield and reduced nematode population.

Asha *et al.*, (2011) isolated from rhizosphere soil samples collected from various tomato-growing fields and evaluated for their efficacy in increasing seed quality variables of tomato and in inhibiting the mycelial growth of *Fusarium oxysporum*. *Pseudomonas* isolate 2 produced effective results and was selected and mass multiplied. Talc and sodium alginate formulations of mass multiplied using different agents were prepared and evaluated for their effects against fusarium wilt under greenhouse conditions. Fresh cultures of Pf2 isolate was found to increase seedling emergence and reduce fusarium wilt disease incidence when compared to the control and the formulations.

Asha *et al.*, (2011) the rhizoplane soil and surrounding soil of healthy and *Fusarium oxysporum* diseased tomato plants of district regions of Karnataka were collected. The best bacterial strains, based on their ability to control development of *Fusarium oxysporum* isolate, were identified as BS1, BS5 and BS18. All bacterial isolates resulted effective for the in vitro control of growth of *Fusarium oxysporum*, where the control mechanisms used by the bacteria do not involve the secretion of fungal cell wall.
hydrolytic enzymes. On the other hand, all bacteria grew well in conditions similar to those that can be found at the field level (considering pH, salinity, Fe3+ and temperature) and showed a good capacity of tomato root colonization. These results suggest that *Pseudomonas fluorescens* isolates studied have an excellent potential to be used as bio-control agents of *Fusarium oxysporum* in tomato greenhouses at the field level.

Saharan and Nehru (2011) reported that Plant growth-promoting rhizobacteria (PGPR) are naturally occurring soil bacteria that aggressively colonize plant roots and benefit plants by providing growth promotion. Inoculation of crop plants with certain strains of PGPR at an early stage of development improves biomass production through direct effects on root and shoots growth. Inoculation of ornamentals, forest trees, vegetables, and agricultural crops with PGPR may result in multiple effects on early-season plant growth, as seen in the enhancement of seedling germination, stand health, plant vigor, plant height, shoot weight, nutrient content of shoot tissues, early bloom, chlorophyll content, and increased nodulation in legumes. PGPR are reported to influence the growth, yield, and nutrient uptake by an array of mechanisms. They help in increasing nitrogen fixation in legumes, help in promoting free-living nitrogen-fixing bacteria, increase supply of other nutrients, such as phosphorus, sulphur, iron and copper, produce plant hormones, enhance other beneficial bacteria or fungi, control fungal and bacterial diseases and help in controlling insect pests. There has been much research interest in PGPR and there is now an increasing number of PGPR being commercialized for various crops. Several reviews have discussed specific aspects of growth promotion by PGPR. In this review, we have discussed various bacteria which act as PGPR, mechanisms and the desirable properties exhibited by them.

Govindappa et al., (2011) reported that in Anucop, captan and Mancozeb M-45 were found extremely effective in reducing *Fusarium oxysporum* f.sp. *carthami* wilt. The seed treatments improved seed germination, seedling vigour and plant stand. Due to these treatments many of the seed-borne fungi failed to express in the normal way. Bio-agents formulations viz., *Trichoderma harzianum*, *Bacillus subtilis* and *Pseudomonas fluorescens* reduced the wilt incidence both under greenhouse and field conditions, thereby enhancing the growth of the seedlings. These antagonists significantly reduced
the population of *Fusarium oxysporum* f.sp. *carthami*, increased the seed germination and seedling vigour. Leaf extracts of *Becopa monniera* and *Adathoda vasica* were found effective in the control of safflower wilt. Comparatively *B. monniera* enhanced the seed germination and quality parameters of plants both under greenhouse and field conditions and also effectively suppressed the wilt up to flowering.

Podile and Dube (1987) reported that a local isolate AF1 and BACT1 (obtained from Canada) of *B. subtilis* caused winder inhibition zones. *Pseudomonas dreschleri* f. sp. *cajani* failed to grow in 10-fold concentrated cell – free culture filtrate of AF 1, and in 5 fold concentrated extract, the inhibitory effect on radial growth was proportional to concentration. Increasing concentration of cell – free culture filtrate of AF 1 in Richard’s solution decreased the dry weight of the fungus.

Siddiqui and Husain (1991) reported that a four biocontrol agent’s viz. *Bacillus licheniformis*, *Pseudomonas mindocina*, *Acrophialophora fusispora* and *Aspergillus flavus* were applied for the control of root-knot nematode individually as well as in various combinations. Individually *B.licheniformis* was found best as a biocontrol agent.

Kapoor and Kumar (1991) reported that *Aspergillus fischeri* and an isolate of *Bacillus* sp. (BM-1) caused maximum inhibition of tomato wilt pathogens, *Fusarium oxysporum* and *F.solani* under in vitro conditions. Fungal and bacterial antagonists expressed clear antagonistic activity in the temperature regimes of 20-27c and 20-025c, respectively, but were most effective at lowest temperature (20c) tested. In general, antagonistic activities decreased with an increase in temperature. *F.solani* isolate KHF.41 and *F. oxysporum* isolate DFO-13 were most sensitive to fungal and bacterial antagonists, respectively.

Hervas *et al.*, (1998) reported three antagonistic microorganisms, namely *Bacillus subtilis*, non-pathogenic *Fusarium oxysporum* isolate Fo 90105 and *Trichodermaharzianum*, were applied alone or in combination to chickpea genotypes ICCV4 and PV61 with differing levels of resistance to *Fusarium* wilt (*F. oxysporum* f.sp. *ciceri*) to determine if they could effectively suppress disease development caused by the
highly virulent *F. oxysporum* f.sp.*ciceri* race 5. All 3 antagonists effectively colonized the roots of both chickpea genotypes, whether alone or in combination, and significantly suppressed development of *Fusarium* wilt. The extent of disease suppression was higher and more consistent in PV61 than in ICCV4.

Ferrandis et al., (1999) reported the type strain *Bacillus thuringiensis* var. bolivia (serotype H63), isolated from the Bolivian high valleys, has been characterized at different levels. Its parasporal crystal has an unusual shape and it is composed of a protein of 155 kDa which shows two bands of 75 and 80 kDa after activation. Analysis by PCR shows the presence of cry1 genes, and amplification with specific primers gave products for cry1 E, cry1 D, cry4A and cry4 B with sizes different to those expected. Immunoblotting tests showed positive reaction for Cry1 E, Cry3 A, Cry4 A and Cry11 A crystal proteins. The plasmid pattern revealed two large and two small plasmids. Toxicity tests were performed against 14 insects and a slight toxicity was found against *Plutella xylostella* and *Trichoplusia ni*.

Sakia et al., (2000) observed Inhibitory effect on growth of *Colletotrichum falcatum* Went, was studied with five bio-control agents viz. *Trichoderma viride* (Tv.), *Trichoderma harzianum* strain-1 (Th1). *Trichoderma harzianum* strain-2 (Th2). *Trichoderma harzianum* strain-3 (Th3), and *Bacillus subtilis* (Bs). Three inoculation methods viz. spotting, streaking and flooding were used, of which the streaking method showed the highest inhibition while spotting method showed the lowest with all the biocontrol agents and in both single and dual inoculation. *Trichoderma harzianum strain-1* showed the maximum growth inhibition (87.2%) while the minimum (40.84%) growth inhibition was exhibited by *Bacillus subtilis* when applied singly. Dual application of *Trichoderma spp.* with *Bacillus subtilis* was found to be more effective over the individual application. *Trichoderma harzianum* strain-1 with *Bacillus subtilis* showed the maximum growth inhibition (87.7%) while *Trichoderma harzianum* strain-2 with *Bacillus subtilis* showed the minimum (72.0%).

Rajendran et al., (2001) observed *Meloidogyne incognita* and *Tylenchulus semipenetrans* in horticultural crops, such as citrus, tomato, potato, chilli and aubergine using
Pseudomonas fluorescens, Pasteuria penetrans, Bacillus subtilis, B. cereus and vesicular arbuscular mycorrhizal fungi, Glomus fasciculatum and Glomus mosseae are presented. Result showed that these organisms could be used as successful biological control agents for the management of plant parasitic nematodes.

Siddiqui et al., (2001) reported that thirty-two isolates of Pseudomonas aeruginosa and Bacillus subtilis strain were isolated from rhizosphere and rhizoplane of four wild and 15 cultivated plants. Bio-control and growth-promoting potentials of the bacterial isolates were tested under laboratory, green- house and field conditions. The bacterial isolates not only exhibited nematicidal activity by killing the second stage larvae of Meloidogyne javanica to a varying degree but also produced inhibition zones by inhibiting the radial growth of Macrophomina phaseolina, Fusarium solani and Rhizoctonia solani. Strain IE-2 and IE-6 of P. aeruginosa also lysed the fungal mycelium. P. aeruginosa and B. subtilis used as seed dressing or as soil drench significantly suppressed root rot-root knot infection and nematode population densities under greenhouse and field conditions and thereby enhanced plant growth and yield in mungbean.

Manav and Thind (2002) evaluated in vitro and in vivo the efficacy of four antagonists namely Bacillus subtilis, Pseudomons fluorescens, Trichoderma harzianum and Penicillum notatum against Xanthomonas oryzae pv. Orzyae the causal agent of bacterial blight of rice. Field evaluation and lab experiment showed that only Pseudomonas fluorescens and Trichoderma harzianum significantly reduced the intensity of disease.

Sindhan et al., (2002) observed the efficacy of Trichoderma viride, Trichoderma harzianum, Aspergillus flavus, Aspergillus niger, Aspergillus ochraceus, Penicillum citrinum, Bacillus subtilis and Pseudomonas fluorescens against Rhizoctonia bataticola in vitro condition and in green house condition. In in vitro condition all antagonists inhibited mycelial growth and sclerotia production. Among them, Pseudomonas fluorescens was the most effective (90.5%) in green house condition Pseudomonas fluorescens resulted the highest level of diseases control (71.8%) and increased in the dry weight and length of roots and shoots.
Agrawal et al., (2002) evaluated the efficacy of fungal antagonists (*Trichoderma viride, T. harzianum, Bacillus subtilis* and *Pseudomonas fluorescens*), singly or in combination with fungicides (carboxin, carbendazim, Topsin M-70 [thiophanate-methyl] and thiram) against wilt (caused by *Fusarium oxysporum* f.sp. ciceris) in highly susceptible (JG 62) and slightly susceptible (Ujjain 21) chickpea cultivars, and to study the effects of wheat (cv. Narmada 112), barley (cv. RD 57), linseed (cv. R 17) and Indian mustard (cv. Varuna) intercrops/mixed crops (1:1) on wilt incidence in JG 62. Thiram was applied at 3 g/kg seeds, whereas the other fungicides were applied at 2 g/kg seeds. The fungal antagonists did not reduce wilt incidence in JG 62, but significantly reduced disease incidence in Ujjain 21. The lowest disease incidence (6.5%) was recorded for *P. fluorescens, T. harzianum + P. fluorescens*, and *B. subtilis + P. fluorescens*. In JG 62, wilt incidence was reduced only when *T. viride* and *T. harzianum* were applied with the fungicides.

Singh (2003) reported the efficacy of *Trichoderma harzianum, T. viride, T.hamatum, Gliocladium virens, Pseudomonas fluorescens* and *Bacillus subtilis* in controlling *Fusarium oxysporum* f.sp.ciceri causing wilt in chickpea was determined *in vitro* and in field experiments conducted in Kanpur, Uttar Pradesh, India during 2001-02. *T. harzianum* recorded the highest control of the pathogen both in vitro and under field conditions.

Prasad et al., (2003) observed *Bacillus thuringiensis* is the most widely used bio-pesticide and to make a photo stable product, two UV protectants, ranipal and congo red, were used in the preparation of WDP formulation of *B. thuringiensis* and were evaluated against *Helicoverpa armigera*. The optimum concentration of both the UV protectants in formulations were found to be 1% (w/w). Addition of UV protectants had significantly improved the bioefficacy of the WDP formulations. Overall performance of WDP formulation containing 1% (w/w) Congo red was superior as compared to ranipal and control.

Kloepper et al., (2004) reported that Elicitation of induced systemic resistance (ISR) by plant-associated bacteria was initially demonstrated using *Pseudomonas* spp. and other
gram-negative bacteria. Several reviews have summarized various aspects of the large volume of literature on *Pseudomonas* spp. as elicitors of ISR, showing that specific strains of the species *B. amyloliquefaciens*, *B. subtilis*, *B. pasteurii*, *B. cereus*, *B. pumilus*, *B. mycoides*, and *B. sphaericus* elicit significant reductions in the incidence or severity of various diseases on a diversity of hosts. Elicitation of ISR by these strains has been demonstrated in greenhouse or field trials on tomato, bell pepper, muskmelon, watermelon, sugar beet, tobacco, *Arabidopsis* sp., cucumber, loblolly pine, and two tropical crops (long cayenne pepper and green kuang futsoi). Protection resulting from ISR elicited by *Bacillus* spp. has been reported against fungal and bacterial pathogens, systemic viruses, a crown-rotting fungal pathogen, root-knot nematodes, and a stem-blight fungal pathogen as well as damping-off, blue mold, and late blight diseases. Reductions in populations of three insect vectors have also been noted in the field: striped and spotted cucumber beetles that transmit cucurbit wilt disease and the silver leaf whitefly that transmits *Tomato mottle virus*. In most cases, *Bacillus* spp. that elicits ISR also elicits plant growth promotion. Further they reported that in other cases, ISR elicited by *Bacillus* spp. is dependent on salicylic acid and independent of jasmonic acid and *NPR1*. In addition, while ISR by *Pseudomonas* spp. does not lead to accumulation of the defense gene *PR1* in plants, in some cases, ISR by *Bacillus* spp. does. Based on the strains and results summarized in this review, two products for commercial agriculture have been developed, one aimed mainly at plant growth promotion for transplanted vegetables and one, which has received registration from the U.S. Environmental Protection Agency, for disease protection on soybean.

Mathiyazhagana *et al.*, (2004) *reported that Bacillus subtilis* (BSCBE4), *Pseudomonas chlororaphis* (PA23), *endophytic P. fluorescens* (ENPF1) inhibited the mycelial growth of stem blight pathogen *Corynespora cassicola* (Berk and Curt) Wei under in vitro. All these bacterial isolates produced both hydroxamate and carboxylate type of siderophores. But the siderophore production was maximum with the isolate ENPF1. Delivering of talc based formulation of BSCBE4 through seedling dip and foliar application effectively reduced stem blight disease incidence and increased the dry matter production under pot culture and field conditions. Application of BSCBE4, PA23 and ENPF1increased the defense related enzymes such as peroxidase, polyphenol oxidase, chitinase and B-1,3
glucanase in *P. amarus* up to ten days after challenge inoculation with *C. cassicola*. Native gel electrophoretic analysis revealed that challenge inoculation of pathogen with BSCBE4 and PA23 induced both peroxidase and polyphnol oxidase isoforms.

Khan *et al.*, (2005) carried out during 2 consecutive years to assess the effect of root-knot nematode infection (2,000 *Meloidogyne incognita* eggs/kg soil) on three winter ornamental plants: hollyhock (*Althea rosea*), petunia (*Petunia hybrida*), and poppy (*Papaver rhoes*). Effects of root-dip treatment with the bio-control agents *Pochonia chlamydosporia*, *Bacillus subtilis*, and *Pseudomonas fluorescens* and the nematicide fenamiphos were tested. The three ornamental species were highly susceptible to *M. incognita*, developing 397 and 285 (hollyhock), 191 and 149 (petunia), and 155 and 131 (poppy) galls and egg masses per root system, respectively, and exhibited 37% (petunia), 29% (poppy), and 23% (hollyhock) (*P* = 0.05) decrease in the flower production. Application of fenamiphos, *P. chlamydosporia*, *P. fluorescens*, and *B. subtilis* suppressed nematode pathogenesis (galls + egg masses) by 64%, 37%, 27%, and 24%, respectively, leading to 14% to 29%, 7% to 15%, 14% to 36%, and 7% to 33% increase in the flower production of the ornamental plants, respectively. Treatment with *P. fluorescens* also increased the flowering of uninfected plants by 11% to 19%. Soil population of *M. incognita* was decreased (*P* = 0.05) due to various treatments from 2 months onward, being greatest with fenamiphos, followed by *P. chlamydosporia*, *B. subtilis*, and *P. fluorescens*. Frequency of colonization of eggs, egg masses, and females by the bioagents was greatest by *P. chlamydosporia*, i.e., 25% to 29%, 47% to 60%, and 36% to 41%, respectively. Colonization of egg masses by *B. subtilis* and *P. fluorescens* was 28% to 31% and 11% to 13%, respectively, but the frequency was 0.3% to 1.3% in eggs. Rhizosphere population of the bioagents was increased (*P* = 0.05) over time, being usually greater in the presence of nematode.

Kiran *et al.*, (2005) reported the isolates of *Aspergillus* found to be dominant on stored chillies were screened for antimicrobial activity. The toxin from *A. flavus* and *A. niger* exhibited antibacterial *Bacillus cereus* (MTCC 430), *B. subtilis* (MTCC 441), *Pseudomonas aeruginosa* (MTCC424), *Escherichia coli* (MTCC 40) and Candida albicans (MTCC 183) procedure suggested bt AOAC (1984) antifungal activity.
Incidences of *Alternaria alternata*, *Fusarium spp.* and *Mucor spp.* was low on stored chillies when compared to *Aspergillus spp.* Chilli seeds aseptically collected from the pods were also tested for mycoflora. Natural occurrence of aflatoxin B$_1$ in chilli pods kept in cold storage was tested. Results from HPLC analysis revealed that the samples were contaminated with aflatoxin B$_1$ to the extent of 5.5 µg Kg$^{-1}$.

Tseng *et al.*, (2006) observed a gene that codes for a novel intracellular poly-3-hydroxybutyrate (PHB) depolymerase has now been identified in the genome of *Bacillus thuringiensis subsp. israelensis* ATCC 35646. This gene, previously annotated as a hypothetical 3-oxoadipate enol-lactonase (Pcal) gene and now designated phaZ, encodes a protein that shows no significant similarity with any known PHB depolymerase. Purified His tagged PhaZ could efficiently degrade trypsin-activated native PHB granules as well as artificial amorphous PHB granules and release 3-hydroxybutyrate monomer as a hydrolytic product, but it could not hydrolyze semicrystalline PHB. In contrast, purified His tagged Pcal) of *pseudomonas putida* was unable to degrade trypsin-activated native PHB granules and artificial amorphous PHB granules, The *B. thuringiensis* PhaZ was inactive against p-nitrophenylpalmitate, tributyrin, and triolein. Sonication supernatants of the wild –type B. *thuringiensis* cells exhibited a PHB- hydrolyzing activity in-vitro, where as those prepared from a phaZ mutant lost this activity.

Mareeswari *et al.*, (2006) observed that the efficacy of four different *Bacillus* isolates and seven different *Pseudomonas* strains were tested against *Pythium* aphanidermatum (Pa) under in vitro conditions. The results showed that among the four *Bacillus isolates*, *Bacillus subtilis* recorded the least mycelial growth (48.7mm) of Pa and the maximum inhibition zone (11mm) as compared to control (89mm). Among the seven *Pseudomonas* strains tested, Pf 1 showed the least mycelial growth of 31mm of pa and the maximum inhibition zone of 25mm as against control (89.3mm). The germination percentage and vigour index of tomato seeds were also studied by roll towel method. *Bacillus subtilis* is recorded the maximum germination percent of 92 with the vigour index of 1401.62 as compared to control (sterile water) i.e.60 percent of 96 with the vigour index of 1496.16 followed by FP7.92 percent and 1376.32 respectively as compared to control (sterile water) i.e. 68 percent and 843.54, respectively.
Kawai et al., (2006) determine the ability of Bacillus spp. to inhibit Verticillium dahliae. First, antagonistic activities of Bacillus spp. were studied in greenhouse trials. They suggest that the bacterium can control soil-borne diseases. Secondly, Bacillus spp. was also examined for their activity to control Verticillium black spot of Japanese radish and plant-growth promotion rhizobacteria (PGPR) effects in the field. After 2 months, these bacteria reduced Verticillium black spot of Japanese radish. The disease severity of those biological control agent (BCA) treatments was less than in the pathogen control treatment.

Kamil et al., (2007) observed that a Four hundred bacterial isolates were isolated from rhizosphere of some plants collected from Egypt and screened for production of chitinase enzyme. Only four isolates designated MS1, MS2, MS3 and MS4 were the most potent chitinolytic bacterial species. SDS-PAGE analysis of vegetative and sporulated cells of the four isolates revealed that the protein profile of the four isolates were different from each other in their banding pattern and were identified as Bacillus licheniformis, Stenotrophomonas maltophilia, Bacillus licheniformis and B. thuringiensis. In vitro MS1 and MS3 were the most active species, so they suppressed the growth of all tested pathogenic fungi (Rhizoctonia solani, Macrophomina phaseolina, Fusarium culmorum, Pythium sp, Alternaria alternata and Sclerotium rolfsii). Also, MS3 produced the high level of chitinase enzyme (1.27 μ/ml) after 4 days incubation as compared with the other isolates. In green-house experiment, B. licheniformis (MS3) significantly reduced the damping off disease caused by Rhizoctonia solani, in Helianthus annus using the seed coat or soil draing treatments.

Chung et al., (2008) isolates 500 bacterial from 20 Korean greenhouse soils for inhibition of diverse plant pathogens. One isolate, Bacillus subtilis ME488, suppressed the growth of 39 of 42 plant pathogens tested. Isolate ME488 also suppressed the disease caused by Fusarium oxysporum f. sp. cucumerinum on cucumber and Phytophthora capsici on pepper in pot assays. Polymerase chain reaction was used to screen isolate ME488 for genes involved in biosynthesis of 11 antibiotics produced by various isolates of B. subtilis. Amplicons of the expected sizes were detected for bacD and bacAB, ituC and ituD, and mrsA and mrsM involved in the biosynthesis of bacilysin, iturin, and
mersacidin, respectively. The identity of these genes was confirmed by DNA sequence analysis of the amplicons. Bacilysin and iturin were detected in culture filtrates from isolate ME488 by gas chromatography coupled with mass spectroscopy and by thin layer chromatography, respectively. Detection of mersacidin in ME488 culture filtrates was not attempted. Experiments reported here indicate that B. subtilis ME488 has potential for biological control of pathogens of cucumber and pepper possibly due to the production of antibiotics.

Muthukumar et al., (2008) reported that four fungal antagonists viz., Trichoderma sp. (N1) Trichoderma viride, Trichoderma harzianum and Trichoderma hamatum and four bacterial antagonists namely Pseudomonas fluorescens - 1 (NI), Pseudomonas fluorescens - 2 (NI), Pseudomonas fluorescens (Pfl) and Bacillus subtilis were evaluated. In vitro for the management of damping-off in chilli caused by Pythium aphanidermatum. All the antagonists showed their antagonism against the pathogen. Among the fungal antagonists, Trichoderma sp. (Native Isolate) showed maximum inhibition of the growth of pathogen with 43.33 per cent over control, which was followed by Trichoderma viride with an inhibition of 37.78 per cent over control. Among the bacterial antagonists, Pseudomonas fluorescens 1 (Native Isolate) showed maximum inhibition of 50.0 per cent over control followed by Pseudomonas fluorescens 2 (native Isolate) with an inhibition of 48.89 per cent over control. Seed treatment with Trichoderma sp. (NI) at 4g / kg + P. fluorescens 1 (NI) @10 g/kg was found to be superior than all the treatments in reducing the population of P aphanidermatum followed by Trichoderma sp. (NI) at 2 g /kg + P. fluorescens - 1 (NI ) at 5g /kg.

Zaghloul et al., (2008) reported the efficiency of bio-control agents for controlling root-rot and wilting diseases of tomato and further indicated that Trichoderma harzianum-I, Pseudomonas fluorescens-II and Bacillus subtilis-I were the best strains for controlling Rhizoctonia solani , Sclerotium rolfsii and Fusarium oxysporum f.sp. lycopersici . Also, the seed dressing of tomato and soil drenching with bio-control agents gave the lowest records of disease severity of tomato. Application of such inocula minimizes the hazard
effects of fungicides, protect the environment from pollution and maintenance of the human health.

Yang et al. (2009) studied that a group of beneficial plant bacteria has been shown to increase crop growth referring to as plant growth promoting rhizobacteria (PGPR). PGPR can decrease plant disease directly, through the production of antagonistic compounds, and indirectly, through the elicitation of a plant defense response termed induced systemic resistance (ISR). While the mechanism of PGPR-elicited ISR has been studied extensively in the model plant Arabidopsis, it is less well characterized in crop plants such as pepper. In an effort to better understand the mechanism of ISR in crop plants, we investigated the induction of ISR by Bacillus cereus strain BS107 against Xanthomonas axonopodis pv. vesicatoria in pepper leaves. We focused on the priming effect of B. cereus strain BS107 on plant defense genes as an ISR mechanism. Often known pepper defense genes that were previously reported to be involved in pathogen defense signaling, the expression of Capsicum annum pathogenesis-protein 4 and CaPR1 was systemically primed by the application of strain BS107 onto pepper roots confirming by quantitative reverse transcriptase PCR. Our results provide novel genetic evidence of the priming effect of a rhizobacterium on the expression of pepper defense genes involved in ISR.

Thanh et al. (2009) studied that the Bacterial wilt, Fusarium wilt and Foot rot caused by Ralstonia solanacearum, Fusarium oxysporum, and Phytophthora capsici respectively, continue to be severe problems to tomato, potato and black pepper growers in Vietnam. Three bio-products, Bacillus vallismortis EXTN-1 (EXTN-1), Bacillus sp. and Paenibacillus sp. (ESSC) and Bacillus subtilis (MFMF) were examined in greenhouse bioassay for the ability to reduce bacterial wilt, fusarium wilt and foot rot disease severity. While these bio-products significantly reduced disease severities, EXTN-1 was the most effective, providing a mean level of disease reduction 80.0 to 90.0% against bacterial wilt, fusarium wilt and foot rot diseases under greenhouse conditions. ESSC and MFMF also significantly reduced fusarium wilt, bacterial wilt and foot rot severity under greenhouse conditions. Bio-product, EXTN-1 with the greatest efficacy under greenhouse condition was tested for the ability to reduce bacterial wilt, fusarium wilt and foot rot under field condition at Song Phuong and Thuong Tin locations in Ha Tay province,
Vietnam. Under field condition, EXTN-1 provided a mean level of disease reduction more than 45.0% against all three diseases compared to water treated control. Besides, EXTN-1 treatment increased the yield in tomato fruits 17.3% than water treated control plants.

Prakob (2009) observed the effects of *Pseudomonas aeruginosa*, *Bacillus subtilis* and antagonistic fungus *Paecilomyces lilacinus* (provitan), on the growth and gall development of lettuce infected by root-knot nematodes *Meloidogyne* spp. was studied both in greenhouse and field environments. In field experiments, lettuce seedlings were cultivated in nematode infested soil, and *P. aeruginosa* and *B. subtilis* were applied every week prior to harvesting. *Paecilomyces lilacinus* was mixed with nematode infested soil two weeks prior to, and again two weeks after planting the lettuce.

Abeysinghe (2009) reported that a combination of two compatible biological control agents, *Bacillus subtilis* CA32 and *Trichoderma harizanum* RU01, both antagonistic to the pathogen *Rhizoctonia solani*, was used to the control damping-off in *Solanum melongena* and *Capsicum annum*. Radial growth of the mycelium of *R. solani* was inhibited by *T. harizanum* RU01 in dual Petri plate assay. *T. harizanum* RU01 was capable to invading the whole surface of the pathogen colony. Sporulating on it and suppress the production of sclerotia of *R.solani*. Microscopic studied showed the hyphae of *R. solani* surrounded by the *T.harizanum* RU01 and subsequent disintegration. *B.subtilis* CA32 produced a zone of inhibition only with the pathogen and no sings of antagonism between the bacteria and *T. harizanum* RU01 on dual petri plate assay. Significant plant production was achieved when either *B. subtilis* added to the seeds or *T.harizanum* added to soil. However, when combine application of biocontrol agents seed bactrization and *T.harizanum* application to soil, significantly enhanced the plant protection from *R.solani*. Soil application of *B.subtilis* and seed application of *T.harizanum* either singly or in combination did not protect from *R.solani* infection indicating that importance of mode of application of biocontrol agents.

Chawla and Gangopadhaya (2009) reported that antagonistic potentiality of *Trichoderma harizanum*, *T.viride*, *Pseudomonas fluorescens* and *Bacillus subtilis* against *Fusarium*
oxysporium f.sp. Cumini was tested under laboratory and greenhouse conditions. The effect of organic amendments viz., farm yard manure, and vermicompost and mustard cake on disease control efficacy of four antagonists against Fusarium wilt was studied. Maximum inhibition of mycelial growth of F. oxysporum f. sp. cumini was recorded in presence of P. fluorescens closely followed by T.harzianum. Seed treatment with talc based formulations of P. fluorescens and T. harzianum provided excellent control of Fusarium wilt under green house condition. These bioagents suppressed the pathogen population in soil and also enhanced the shoot and the root lengths and dry weight of cumin plants. Disease incidences as well as pathogen population in soil were significantly reduced in response to seed treatment with bioagents and simultaneous application of organic amendments. These treatments also led to considerable increase in shoot and root lengths and dry weight of cumin plants. The biocontrol potentiality of T.harzianum and P. fluorescens was relatively better in presence of farm yard manure or mustard cake. While disease control due to seed treatment with T.viride, T.harzianum or P.fluorescens was similar in presence of vermicompost.

Ramezani Hesamedin (2009) reported that two bacterial bioagents namely Pseudomonas fluorescens and Bacillus subtilis were evaluated against the chickpea vascular wilt pathogen, Fusarium oxysporum f.sp. ciceri in vitro condition using Dual Culture Technique. Among the fungal bioagents, T. harzianum produced the maximum inhibition zone of 17 mm compared to the minimum of 7 mm by T. hamatum. There was no significant difference between the inhibition zones produced by P. fluorescens and B. subtilis. Soil application of talc- based formulation of T. harzianum, P. fluorescens and G. virens effectively controlled the vascular wilt of chickpea under field condition.

Asha et al.,(2010) the ability biocontrol agents in suppressing the growth of Fusarium oxysporum f. sp. vanillae causing stem rot in Vanilla in vitro by employing dual culture technique. Trichoderma harzianum, Pseudomonas fluorescens and Bacillus subtilis inhibited the growth of pathogen. In nature microbial interactions involve competition, hyper parasitism or antibiosis and these phenomena play an important role in striking ecological balance and keeping several plant pathogens in check. In recent times biological control of plant pathogenic fungi has received a considerable attention, as it
has several advantages such as possibility of multiple pathogen suppression, low cost and promotion of soil fertility.

Calvo et al., (2010) isolated from the rhizosphere of native potato varieties growing, sixty three Bacillus strains were screened for in vitro antagonism against R.solani was found. Ninety one percent of those strain also inhibited the growth of F.solani. The antagonistic strains were also tested for other plant growth promotion activities. Eighty one percent produced some level of the auxin indol-3-acetic acid, and 58% solublized tricalcium phosphate. Phylogenetic analysis revealed that the majority of the strains belonged to the B.amyloliquefaciens species, while strains Bac17M11, Bac20M11 and Bac20M2 may correspond to a putative new Bacillus species.

Ei-Mohamedy et al., (2011) Among the antagonistic micro-organisms isolated from rhizospheric soil of healthy broccoli plants two fungal isolate (Trichoderma harzianum and Trichoderma viride) and two bacterial isolate (Bacillus subtilis and Pseudomonas fluorescens) were used as bio-control agents for controlling broccoli root rot disease caused by Pythium ultimum and Rhizoctonia solani pathogens. Moreover, their effect on broccoli plant growth and yield were also studied. Treatments of broccoli hybrid Atlantic F1 seedling were preformed as soil mixing (SM) or root dipping (RD) or soil mixing (SM) plus root dipping (RD) methods under greenhouse and field experiments during winter seasons of 2008/2009 and 2009/2010. Obtained results clearly indicated that applied bio-control agents could be arranged according to their activity for suppressing the disease incidence as follows, T. harzainum, B. subtilis, T. viride and P. fluorescent, respectively. Also, it noticed that T. harzainum and control treatments gave the highest and lowest values for vegetative growth, head yield and quality parameters of broccoli plants, respectively. In the same regard, applied of bio-control agents as a combination of soil mixing plus root dipping method was generally more effective than applied individually for suppressing Pythium and Rhizoctonia rots incidence. In addition, using of soil mixing plus root dipping method gave the highest values of all measured parameters followed by soil mixing and root dipping methods. Concerning the interaction effect between used antagonistic micro-organisms and method of treatments, there was a highly significant effect. These results suggested that using of T. harzainum as a bio-control
agent through soil mixing plus root dipping treatment could be provided not only additional protection against crop loss due to *Pythium* and *Rhizoctonia* diseases but also significantly increased vegetative growth, head yield and quality parameters of broccoli plants.