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Antagonistic Activity of Microbial and Organic formulations against Foliar and Soil Borne Plant Pathogens in Baby Corn (*Zea mays* L.) under Green House Condition

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Abstract

An investigation was carried out to study the antagonistic activity of Biocontrol agents, Plant Growth Promoting Rhizomicroorganisms (PGPR's) against plant foliar and soil borne plant pathogens and jeevamrutha as additional nutrients in baby corn (*Zea mays* L.) seedlings. Three biocontrol agents *viz.*, *Trichoderma harzianum, Pseudomonas fluorescens* and *Bacillus subtilis. Trichoderma harzianum* significantly recorded highest antifungal activity against *Exserohilum turcicum, Fusarium moniliforme* and *Pythium aphanidermatum* (68.10, 63, and 62%) followed by *Pseudomonas fluorescens* (66.66 and 53%) and *Bacillus subtilis* (58.10 , 50.45 and 50.50%), Membrane filtered jeevamrutha organic liquid was recorded lowest antifungal activity against pathogens (33.33, 44.00 and 35.00%). Under green house condition combined inoculation of biocontrol agents, PGPR's recorded significantly highest per cent germination, lesser days taken for 50 per cent germination, lowest pre and post emergence disease incidence and highest biocontrol efficiency (%) in respective plant pathogens at 30 days after sowing of baby corn (*Zea mays* L.) seedlings.

Keywords: Antagonistic activity, Biocontrol agents, PGPR's, Jeevamrutha, Pathogens.

Maize (*Zea mays* L.) is the third most important cereal crop next to rice and wheat in India and an important cereal in global agricultural economy. Baby corn is a dehusked maize ear, harvested young especially just emerged and no fertilization has taken place. Baby corn ears in light yellow colour with regular row arrangement of 10 to 12 cm long and a diameter of 1.0 to 1.5 cm arrangement are preferred in the market (Golada *et al*., 2013). Baby corn is an important crop of Thailand, Taiwan and India. Recently, baby corn has gained popularity as valuable vegetable in Delhi, Uttar Pradesh, Haryana, Maharashtra, Karnataka, Andhra Pradesh, Rajasthan and Meghalaya States of India. In India, it is grown in 9.43 million hectare area with the production and productivity of 24.35 million tonnes and 2583 kg ha^{-1} respectively.

Growth Promoting Rhizomicroorganisms (PGPR's) act through direct improvement of plant nutrition either by solubilizing these nutrients or fixing atmospheric N_2. In solubilization, several mechanisms may be involved depending on the nature of the nutrient. For example, phosphate can be released from insoluble organic forms by several microbial enzymes like phytases or non-specific phosphatases, while inorganic phosphorus stocks are solubilized through the production of organic acids by beneficial bacteria. Phytostimulation is the direct promotion of plant growth through the modulation of the plant's hormonal balance. Several microorganisms are capable to produce and excrete a variety of plant hormone like compounds including auxin, gibberellins, cytokines etc. Some microbial agents produce enzymes that degrade a precursor of ethylene thus limiting the levels of this hormone in the plant there by increasing plant growth especially under stress conditions (Francis *et al.,* 2010).

Biologically controlled antagonistic microorganism offer a practical as well as economical alternative for management of different diseases. Among biocontrol agents, endophytic microorganisms also have special attention, due to their crucial role on host-plant development. Since these symbionts are systemically distributed in plant via metabolic translocation, production of inhibitory, allele chemicals, and induction of systemic resistance (ISR) in host plants to a broad spectrum of plant pathogens (Rai *et al*., 2007).

Currently, continued use of agrochemicals to control the plant pathogenic fungi, the awareness relies mainly in the noxious effects of fungicides on the environmental and human health. Several efforts have been made to find less hazardous options for controlling these plant pathogens among which use of biological control and other microorganisms has been demonstrated as feasible alternatives. The aim of the study is to analyze the sustainable strategies for controlling of foliar and soil borne diseases using biocontrol agents and PGPR's and the mechanisms to achieve the disease control in baby corn (*Zea mays* L.)

Material and Methods

An experiment was conducted in the Department of Agricultural Microbiology, University of Agricultural Sciences, GKVK, Bangalore-65.

Cultures of biocontrol agents, PGPR's *viz*., *Trichoderma harzianum, Bacillus subtilis, Pseudomonas fluorescens, Gluconacetobacter diazotrophicus, Bacillus megaterium Piriformospora indica* were obtained from the collection of culture at the department and fungi were grown on Potato Dextrose Agar (PDA) and bacteria on Nutrient Agar (NA) at room temperature. Slants were subsequently stored at 5°C in a refrigerator and maintained by sub-culturing once in a month. One set of all cultures were preserved in mineral oil to serve as stock culture.

Collection, isolation, purification and identification of Pathogens from diseased specimens

Pathogens were isolated from the infected seedlings of maize crops collected from the AICRP, ZARS, V. C. Farm, Mandya. The infected seedlings showing damping off, root rot, and blight were collected in polythene bags, labeled and brought to the laboratory and kept at 4°C for the purpose of isolation of the causal organisms.

The pathogens were isolated on Potato Dextrose Agar (PDA) medium. Infected parts were washed with sterile water. Infected plant parts (1 cm length) were excised with a sterile scalpel or blade and were surface sterilized with 0.1 % (w/v) mercuric chloride for 60 sec. Sterilized infected parts were washed twice with sterile water for 60 sec, plated on to sterile petri plates with 15 ml potato dextrose agar in separate plates and incubated at room temperature for 5 days. Plates were observed at regular intervals for the development of the fungal colonies. A Single hyphae tip of fungal culture from the inoculated plate was picked up and pure culture was made on PDA. The identification of the fungal pathogens from crop plants were based on the morphological, cultural and the structural characteristics of the conidiophores under a light microscope.

In vitro activity of fungal and bacterial antagonists against the pathogens by dual culture Method

In vitro inhibition of antifungal activity by fungus and bacterial antagonists and membrane filterated jeevamrutha organic liquid tested against *E. turcicum, F. moniliforme* and *P. aphanidermatum* were evaluated by using dual culture method. Observations were recorded when there was a full growth of pathogen in the control plate (6-7 days). The diameter of the colony of the pathogen was measured in both directions and the per cent inhibition on growth of the test pathogen was calculated using the mentioned formula.

$$I = (C-T) / C \times 100$$

Where, I = Per cent inhibition

C= Growth of fungal plant pathogens in control (mm)

T= Growth of fungal plant pathogens in dual culture plate (mm).

Preparation of Jeevamrutha

Jeevamrutha organic liquid was prepared in a 10 liter container. 500 gm of cow dung and cow urine and 10 liters of water were added into container and mixed thoroughly. 100 gm of horse gram flour and jaggery and 20 gm of garden soil were mixed clock wise to form homogenous solution. Container was kept under shade and covered with wet jute bag. This solution was stirred daily in clockwise direction during morning, afternoon and evening. The solution was incubated upto 9 to 12 days and required quantity of liquid was diluted with water.

Seedling tray experiments on Baby corn *(Zea mays* L.)

A seedling tray experiment was conducted to evaluate the antagonistic activity of biocontrol agents against foliar and soil borne plant pathogens under green house condition of baby corn (*Zea mays* L.) in the Department of Agril. Microbiology.

Preparation of tray substrate

The substrate prepared for the experiment included 10 kilograms of coir pith enriched with 2.5 kilograms each of red earth, vermicompost and pongamia cake. The substrates were sterilized before adding antagonist and PGPR's.

Preparation of Antagonists

Antagonist and PGPR's were grown in sterile potato dextrose broth as well as nutrient broth in one litre conical flask and placed on rotary shaker for 24 hours for bacteria and 7days for fungi. The inoculum containing 5x 10^8cfu / ml of bacteria and 7 x 10^5 cfu/ ml of fungi were added separately at the rate of 10 ml/ kg of substrate.

Preparation of Pathogens Inoculums

Soil borne Plant pathogens

A mixture of 940 g of sand and 60 gm of sorghum (94:6) were mixed and the mixture was sterilized.

Five mycelial discs of 5 mm size of respective pathogens on the PDA plate were separately transferred aseptically to the polybags containing sterilized sorghum and sand mixture and incubated at 25 ± 1.0°C for 15 days.

Foliar Plant pathogen

2-3 bits of foliar pathogen of *Exserohilum turcicum* mycelium was inoculated aseptically to the polybags containing sterilized sorghum grains and were incubated at 25°C ± 1.0°C for 10 days.

Preparation of seedling trays and sowing

Soil borne Plant pathogens

The mass multiplied soil borne plant pathogens inocula *Fusarium moniliforme* and *Pythium aphanidermatum* were separately added to substrate mixture @ 100 gm /kg to each polybags. The mixed substrate was dispensed at the rate of 100 gm per tray at the time of sowing.

Foliar Plant pathogen

The mass multiplied foliar plant pathogen inoculum *Exserohilum turcicum* was sprayed after germination. Biocontrol agents, PGPR's and Jeevamrutha organic liquid were sprayed based on plant pathogen lesions of *Exserohilum turcicum*. Three replications were maintained for each treatment. The trays were watered daily and the observations were made on germination percentage, pre and post emergence disease incidence. The observed data was recorded and tabulated.

Seed treatment

Chemical treated Baby corn G-5414 (Hybrid) seeds were repeatedly washed and surface sterilized with 70 % ethanol for 1 min, 3% Sodium hypochlorite for 5 min, rinsed in sterile distilled water thrice and air dried over night. Required quantity of seeds were soaked in 10 ml of respective treatments for 2-3 hours and dried under laminar air flow. The treated seeds were sown at the rate of 50-60 gm per tray. The seeds soaked in sterile distilled water were maintained as control.

Treatments details:

T_1 - Absolute control (A.c)

T_2 - Control Pathogen (C.p)

T_3 - P + *Gluconacetobacter diazotrophicus* (G.a)

T_4 - P + *Bacillus megaterium* (B.m)

T_5 - P + *Piriformospora indica (P.i)*

T_6 - P + *Pseudomonas fluorescens* (P.f)

T_7 - P + *Bacillus subtilis* (B.s)

T_8 - P + *Trichoderma harzianum* (T.h)

T_9 - P + Jeevamrutha (J)

T_{10} - P + (G.a) + (B.m) + *(P.i)*

T_{11} - P + (T.h) + (P.f) + (B.s)

T_{12} - P + (G.a) + (B.m) + *(P.i)* + (T.v) + (P.f) + (B.s)

Where, P- Pathogen

Observations recorded

Germination percentage was recorded and per cent germination was calculated by using formula.

Germination percentage (%) = No. of seeds germinated / No. of seeds sown x 100

Percent pre-emergence disease incidence

Infectious disease whose incidence is increasing following it's first introduction into a new host population. Pre-emergence disease incidence was calculated by formula.

Pre-emergence disease incidence=100 (GA-GT) / GA

Where, GA - Germination percentage in absolute control

GT - Germination percentage in treatment

Percent post- emergence disease incidence

Infectious disease caused by a pathogen that has not been observed previously within a population *i.e.,* Post-emergence disease incidence was calculated by formula.

Post-emergence disease incidence=100 (GP-ND)/ND

Where, GP - Number of healthy plants left in absolute control

ND - Number of healthy plants left in treatment

Biological control efficiency (BCE)

Biological control efficiency was calculated using the following formula given by Guo *et al.* (2004).

BCE = (DIPC-DIT / DIPC) x 100

Where DIPC - Disease incidence in pathogen control

DIT- Disease incidence in treatment group

Statistical analysis

Analysis of Variance (ANOVA) was by DSTAT-C software and means were separated by Duncan's multiple range test (DMRT).

Results and Discussion

The results of antagonistic activity and effect of Biocontrol agents, PGPR's against Foliar and Soil borne Plant Pathogens *viz.*, Turcicum leaf blight *(Exserohilum turcicum),* Fusarium stalk rot **(***Fusarium moniliforme)* and Damping off **(***Pythium aphanidermatum)* under green house condition, are discussed here under.

Foliar disease of Turcicum leaf blight caused by Exserohilum turcicum

The per cent inhibition and effect of biocontrol agents and PGPR's against foliar plant pathogens of *Exserohilum turcicum* is presented in Table 1 & 2. The *Trichoderma harzianum* shows significantly highest per cent inhibition (68.10%) followed by *Pseudomonas fluorescens* (66.66%), *Bacillus subtilis* (58.10%) and jeevamrutha organic liquid (33.3%). The highest germination per cent was recorded in the absolute control (96.25%) and this was followed by treatment T_{12} (92.50%) and T_{11} (91.25%), T_6 and T_8 (90.00 and 90.42%) were on par with each other. The pathogen inoculated control recorded the significantly least germination (79.17%). The treatment T_2 took more number of days (10) for 50 per cent germination, while T_5 took least number of days (7.00) for 50 per cent germination followed by all other treatments. The least pre-emergence disease incidence was recorded in treatments T_{12} and T_8 (4.34 and 4.00%) which were on par with each other. The highest pre-emergence

Table 1

Antagonistic activity of Biocontrol agents and PGPR's against Foliar and Soil borne Plant Pathogens of Baby corn (*Zea mays* L.)

Biocontrol agents	Per cent inhibition		
	Exserohilum turcicum	Fusarium moniliforme	Pythium aphanidermatum
Trichoderma harzianum	68.10 [a]	63.00 [a]	62.00 [a]
Pseudomonas fluorescens	66.66 [b]	53.00 [b]	53.00 [b]
Bacillus subtilis	58.10 [c]	50.45 [c]	50.50 [c]
Jeevamrutha	33.33 [d]	44.00 [d]	35.00 [d]

Note: Means with the same superscript donot differ significantly @ P=<0.05 as per DMRT

disease incidence was recorded in the control with pathogens (17.75 %) followed by T_5 (12.55 %) and T_4 (10.82 %) which was significantly higher than the rest of the treatments. The lowest post - emergence disease incidence was recorded in treatment T_{12} (3.06 %) followed by T_{11} (4.36 %), T_6 and T_{10} which were on par with each other. The Significantly highest post-emergence disease incidence was recorded in T_2 (17.03 %). Significant difference among pathogen inoculated T_{12} recorded highest biocontrol efficiency (82.05 %) followed by T_{11} (74.36 %). Uninoculated control and control pathogen did not show any biocontrol efficiency and this may due to lack of biocontrol agents and PGPR's in the treatments.

Similar result was also obtained by Harlapur *et al.,* (2007) who reported that maximum mean per cent inhibition of mycelial growth of *Exserohilum turcicum* was recorded in *Trichoderma harzianum* (65.17 %) followed by *T. viride* (56.95 %) and bioextracts.

Ahmad *et al*. (2003) studied that mechanisms are thought to include the ability to produce phytohormones, asymbiotic nitrogen fixation, action against phytopathogenic microorganisms by production of siderophores, synthesis of antibiotics, enzymes and fungicidal compounds. Sun *et al*. (2009) also revealed that biocontrol agents offer diversified inhibition activity of *Exserohilum turcicum* seed treatment with

TABLE II

Effect of Biocontrol agents and PGPR's against Turcicum leaf blight on Baby corn (*Zea mays* L.) in seedling trays under green house condition

Treatments	Per cent Germination	Days taken for 50 per cent germination	Pre-emergence disease incidence (per cent)	Post-emergence disease incidence (per cent)	Biocontrol efficiency (per cent)
T_1	96.25 ^{a}	8.00 ^{b}	0.00 ^{h}	0.00 ^{k}	-
T_2	79.17 ^{h}	10.00 ^{a}	17.75 ^{a}	17.03 ^{a}	0.00 ^{j}
T_3	88.75 ^{cde}	8.00 ^{b}	7.79 ^{def}	6.99 ^{f}	58.97 ^{e}
T_4	85.83 ^{efg}	8.00 ^{b}	10.82 ^{bc}	10.04 ^{d}	41.02 ^{g}
T_5	84.17 ^{g}	7.00 ^{c}	12.55 ^{b}	11.79 ^{b}	30.77 ^{i}
T_6	90.00 ^{bcd}	8.00 ^{b}	6.49 ^{efg}	5.67 ^{g}	66.67 ^{d}
T_7	87.50 ^{def}	8.00 ^{b}	9.09 ^{cde}	8.29 ^{e}	51.28 ^{f}
T_8	90.42 ^{bcd}	8.00 ^{b}	4.00 ^{g}	5.24 ^{h}	69.23 ^{c}
T_9	85.42 ^{fg}	8.00 ^{b}	9.48 ^{cd}	10.48 ^{c}	38.46 ^{h}
T_{10}	90.00 ^{bcd}	8.00 ^{b}	8.11 ^{def}	5.67 ^{g}	66.67 ^{d}
T_{11}	91.25 ^{bc}	8.00 ^{b}	5.63 ^{fg}	4.36 ^{i}	74.36 ^{b}
T_{12}	92.50 ^{b}	8.00 ^{b}	4.34 ^{g}	3.06 ^{j}	82.05 ^{a}

Note: Means with the same superscript donot differ significantly @ P=<0.05 as per DMRT

T_1: Absolute control (A.c)
T_2: Control Pathogen (C.p)
T_3 : Pathogen + *Gluconacetobacter diazotrophicus* (G.a)
T_4: Pathogen + *Bacillus megaterium* (B.m)
T_5 : Pathogen + *Piriformospora indica* (P.i)
T_6: Pathogen + *Pseudomonas fluorescens* (P.f)
T_7: Pathogen + *Bacillus subtilis* (B.s)
T_8: Pathogen + *Trichoderma harzianum* (T.h)
T_9: Pathogen + Jeevamrutha (j)
T_{10}: Pathogen + (G.a) + (B.m) + (P.i)
T_{11}: Pathogen + (T.h) + (P.f) + (P.i)
T_{12}: Pathogen + (G.a) + (B.m) + (P.i) + (T.h) + (P.f) + (B.s)

Trichoderma harzianum SH2303 and able to control leaf spots, which means *Trichoderma* sp. able to trigger leaf resistance to northern leaf blight. The composite seed coating agent comprising *Trichoderma* sp. is more stable control against northern leaf blight.

Soil borne diseases of Fusarium stalk rot caused by *Fusarium moniliforme*

The per cent inhibition and effect of biocontrol agents and PGPR's against soil borne plant pathogen of *Fusarium moniliforme* is presented in Table 1 & 3. The *Trichoderma harzianum* recorded significantly highest per cent inhibition (63.00 %) of *Fusarium moniliforme* followed by *Pseudomonas fluorescens* (53.00 %), *Bacillus subtilis* (50.45 %) and jeevamrutha organic liquid (44.00 %).

The highest germination per cent was recorded in the absolute control (95.83%) followed by T_{12} (82.50%), T_{11} (81.25%) and T_8 (80.42%), T_6 and T_{10} (80.00%) were on par with each other. The pathogen inoculated control recorded significantly least germination per cent (66.66%). The treatments T_2 (10.00) recorded more number of days for its 50 per cent germination but all other treatments were on par with each other.

TABLE 3

Effect of Biocontrol agents and PGPR's against Fusarium stalk rot on Baby corn (*Zea mays* L.) in seedling trays under green house condition

Treatments	Percent Germination	Days taken for 50 per cent germination	Pre-emergence disease incidence (per cent)	Post-emergence disease incidence (per cent)	Biocontrol efficiency (per cent)
T_1	95.83 ^{a}	8.00 ^{b}	0.00 ^{i}	0.00 ^{i}	-
T_2	66.66 ^{g}	10.00 ^{a}	30.43 ^{a}	26.96 ^{a}	0.00 ^{j}
T_3	79.58 ^{cd}	8.00 ^{b}	16.95 ^{e}	16.96 ^{e}	37.10 ^{e}
T_4	75.83 ^{ef}	8.00 ^{b}	20.86 ^{c}	20.00 ^{c}	25.81 ^{g}
T_5	74.16 ^{f}	8.00 ^{b}	22.60 ^{b}	21.73 ^{b}	19.36 ^{i}
T_6	80.00 ^{bcd}	8.00 ^{b}	16.52 ^{ef}	15.65 ^{f}	41.94 ^{d}
T_7	77.50 ^{de}	8.00 ^{b}	19.13 ^{d}	18.26 ^{d}	32.26 ^{f}
T_8	80.42 ^{bc}	8.00 ^{b}	16.08 ^{f}	15.21 ^{f}	43.55 ^{c}
T_9	75.42 ^{ef}	8.00 ^{b}	21.30 ^{c}	20.43 ^{c}	24.20 ^{h}
T_{10}	80.00 ^{bcd}	8.00 ^{b}	16.52 ^{ef}	15.65 ^{f}	41.94 ^{d}
T_{11}	81.25 ^{bc}	8.00 ^{b}	15.21 ^{g}	14.34 ^{g}	46.78 ^{b}
T_{12}	82.50 ^{b}	8.00 ^{b}	13.91 ^{h}	13.04 ^{h}	51.62 ^{a}

Note: Means with the same superscript donot differ significantly @ P=<0.05 as per DMRT

T_1: Absolute control (A.c)
T_2: Control Pathogen (C.p)
T_3 : Pathogen + *Gluconacetobacter diazotrophicus* (G.a)
T_4: Pathogen + *Bacillus megaterium* (B.m)
T_5 : Pathogen + *Piriformospora indica* (P.i)
T_6: Pathogen + *Pseudomonas fluorescens* (P.f)
T_7: Pathogen + *Bacillus subtilis* (B.s)
T_8: Pathogen + *Trichoderma harzianum* (T.h)
T_9: Pathogen + Jeevamrutha (j)
T_{10}: Pathogen + (G.a) + (B.m) + (P.i)
T_{11}: Pathogen + (T.h) + (P.f) + (P.i)
T_{12}: Pathogen + (G.a) + (B.m) + (P.i) + (T.h) + (P.f) + (B.s)

The least pre-emergence disease incidence was recorded in treatments T_{12} (13.91%) fallowed by T_{11} (15.21%) and T_8 (16.08), T_6 and T_{10} (16.52%) which were on par with each other. The highest pre-emergence disease incidence was recorded in the control with pathogens (30.43%) followed by T_5 (22.60%) which was significantly higher than the rest of the treatments. The lowest post-emergence disease incidence was recorded in treatment T_{12} (13.04%) followed by T_{11} (14.36%) and T_8 (15.21%), T_6 and T_{10} (15.65%) were on par with each other. Significantly highest post-emergence disease incidence was recorded in T_2 (26.96%). Significant difference among pathogen inoculated T_{12} recorded highest biocontrol efficiency (51.62%) followed by T_{11} (46.78%). T_1 and T_2 did not show any biocontrol efficiency and this may be due to lack of biocontrol agents and PGPR's in the treatments.

These results are in accordance with Yogendra and Singh (2002) who studied the effect of *Trichoderma* based biocontrol agents, *viz., T. viride* and *T. harzianum* on soil borne pathogens under *in vitro* condition. *T. harzianum* exhibited strong mycoparasitism and recorded highest (100%) antagonistic activity covered colony growth on the pathogen, where as *T. viride* showed strong antibiosis and formed 2-3 mm zone of inhibition after six days of incubation in dual culture.

Abbas and Heinrich (2009) also revealed that seed treatment with biocontrol (*Trichoderma* sp.) agent produced secondary metabolite with enhanced germination. The antifungal metabolite 6-pentyl-alpha-pyrone (6PAP) exhibited phytotoxic effects on germination and elongation growth of coleoptiles on maize kernels before germination. Sundaramoorthy and Balabaskar (2013) reported that disease caused by *Fusarium* sp. was found suppressed due to the application of biocontrol agents.

Soil borne disease of Damping off caused by *Pythium aphanidermatum*

The per cent inhibition and effect of biocontrol agents and PGPR's aganist soil borne plant pathogen of *Pythium aphanidermatum* is presented in Table 1 & 4. *Trichoderma harzianum* showed highest inhibition (62.00%) of *Pythium aphanidermatum* followed by *Pseudomonas fluorescens* (53.00%), *Bacillus subtilis* (50.50%) and jeevamrutha organic liquid (35.00%).

Highest germination per cent (78.33 %) was recorded in T_{12} and lowest germination per cent (58.33 %) was recorded in T_2. Not much significant differences were observed between the treatments regarding days taken for 50 per cent germination. Lowest pre and post emergence disease incidence (18.26 and 9.56%) was recorded in T_{12} and it was significantly less compared to other treatments. T_2 recorded maximum pre and post emergence diseases incidence (39.26 and 47.82 %) compared to other treatments. Highest biocontrol efficiency per cent (75.55 %) was recorded in T_{12} followed by T_{11} (72.22 %).

Similar trends were observed by Muthu kumar *et al*. (2010) who reported the antagonistic activity of *T. harzianum*, *T. viride*, *P. fluorescens* and *B. subtilis* against soil borne fungal pathogens. Ramesh and Korikanthimath (2004) noted that the application of biological control agents as seed and soil treatment reduced both pre and post-emergence damping off in the nursery in *P. fluorescens* treatments followed by *Trichoderma* sp. treatment.

Over all, the results with respect to disease incidence by all pathogens was suppressed in combined inoculation of biocontrol agents and PGPR. Similarly, Mohan (2006) reported a decrease in the disease incidence of brinjal seedlings when treated with a consortia of biocontrol agents and PGPR.

Jeevamrutha organic liquid treatment of respective pathogens enhanced plants growth and slightly reduced the diseases by respective pathogens because of fermentative organisms in jeevamrutha. Similarly, Savitha *et al.* (2015) reported that jeevamrutha is a source of nutrients, but also it is a fermented liquid product containing huge quantity of microbial load acts as plant growth and antifungal activity in its application even at very less rate act as boon to soil for improving soil health and plant growth. Sreenivasa *et al.* (2010) who have also reported the presence of naturally

TABLE 4

Effect of Biocontrol agents and PGPR's against Damping off on Baby corn (*Zea mays* L.) in seedling trays under green house condition

Treatments	Percent Germination	Days taken for 50 per cent germination	Pre-emergence disease incidence (per cent)	Post-emergence disease incidence (per cent)	Biocontrol efficiency (per cent)
T_1	95.83 ^{a}	8.00 ^{c}	0.00 i	0.00 ^{i}	-
T_2	58.33 ^{g}	10.00 ^{a}	39.13 ^{a}	47.82 ^{a}	0.00 ^{h}
T_3	75.42 ^{cd}	7.00 ^{d}	21.30 ^{e}	16.090 ^{e}	58.89 ^{d}
T_4	71.66 ^{ef}	7.00 ^{d}	25.21 ^{d}	16.52 ^{e}	57.77 ^{d}
T_5	70.00 ^{f}	8.000 ^{c}	26.96 ^{b}	18.26 ^{c}	53.33 ^{f}
T_6	75.83 ^{bcd}	8.00 ^{c}	20.87 ^{ef}	12.17 ^{f}	68.89 ^{c}
T_7	73.33 ^{de}	8.00 ^{c}	26.09 ^{c}	17.39 ^{d}	55.50 ^{e}
T_8	76.25 ^{bc}	8.00 ^{c}	20.43 ^{f}	11.73 ^{f}	70.00 ^{c}
T_9	71.25 ^{ef}	9.00 ^{b}	25.65 ^{cd}	21.82 ^{b}	44.22 ^{g}
T_{10}	75.83 ^{bcd}	8.00 ^{c}	20.87 ^{ef}	17.39 ^{d}	55.55 ^{e}
T_{11}	77.08 ^{bc}	8.00 ^{c}	19.56 ^{g}	10.87 ^{g}	72.22 ^{b}
T_{12}	78.33 ^{b}	8.00 ^{c}	18.26 ^{h}	9.56 ^{h}	75.55 ^{a}

Note: Means with the same superscript donot differ significantly @ P=<0.05 as per DMRT

T_1: Absolute control (A.c)

T_2: Control Pathogen (C.p)

T_3 : Pathogen + *Gluconacetobacter diazotrophicus* (G.a)

T_4: Pathogen + *Bacillus megaterium* (B.m)

T_5 : Pathogen + *Piriformospora indica* (P.i)

T_6: Pathogen + *Pseudomonas fluorescens* (P.f)

T_7: Pathogen + *Bacillus subtilis* (B.s)

T_8: Pathogen + *Trichoderma harzianum* (T.h)

T_9: Pathogen + Jeevamrutha (j)

T_{10}: Pathogen + (G.a) + (B.m) + (P.i)

T_{11}: Pathogen + (T.h) + (P.f) + (P.i)

T_{12}: Pathogen + (G.a) + (B.m) + (P.i) + (T.h) + (P.f) + (B.s)

occurring beneficial microorganisms predominantly bacteria, yeast, actinomycetes and certain fungi in organic liquid manures. Hence, these formulations would serve a long way in supplementing many of the biofertilizers and biocontrol agents. Mean while Krishna 2014 who also reported the diseases was slightly controlled by spraying of organic liquid formulations it becauses of secondary metabolites produced by the beneficial micro organisms in might have helped to prevent the diseases.

The present study revealed that the application of both biocontrol agents and PGPR's which are used in combinations will suppresses the plant pathogens against *Exserohilum turcicum, Fusarium moniliforme* and *Pythium aphanidermatum.* Hence, it is note worthy that the PGPR's *Gluconacetobacter diazotrophicus* isolate effectively controlled both soil and foliar pathogens equally to the biocontrol agents. Hence further studies could be carried out on *Gluconacetobacter diazotrophicus.* Jeevamrutha can be used as nutrient sources and disease management for further studies in green house and field conditions on growth and yield of baby corn (*Zea mays* L.).

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