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RESEARCH PAPER

Effect of bio-priming and colonized FYM with bio-control agents on quantative and qualitative traits and disease management in barnyard millet (*Echinochloa crusgalli* L.)

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Abstract : The present investigation was conducted during *Kharif*, 2016 at Research B-Block, Plant Pathology Division, College of Forestry, Ranichauri, V.C.S.G. Uttarakhand University of Horticulture and Forestry. The treatments included bio-agents applied through seed bio-priming alone or in combination with FYM colonized by bio-agents and fungicide (seed treatment with fungicide carbendazim) for assessment of morpho-physiological traits and disease management in barnyard millet var. PRJ-1. Maximum number of leaves per plant, stem diameter, number of effective tiller plant^{-1}, plant height, number of fingers ear^{-1}, ear length, ear diameter, 1000 grain weight, biological yield, grain yield plant^{-1} and grain yield was recorded in treatment T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14) followed by T_8 (Seed bio-priming with *Pseudomonas fluorescens Psf*-4+FYM colonized by *Psf*-4) while, minimum was recorded in T_{10} (control). Similarly T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14) also showed minimum days to 50 per cent flowering, days to maturity and disease (Sheath blight and brown leaf spot) incidence than other treatments including control. From the present investigation, it may be concluded that the tested bio-agents applied through seed bio-priming alone or in combination with FYM pre-colonized by bio-agents enhanced the growth parameters, yield and its contributing traits as well as reduced disease severity in barnyard millet (var. PRJ-1) though the performance of the treatment T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+ FYM colonized by *Th*-14) was found better among all the treatments for most of the parameters studied under present environmental materials and conditions.

Key Words : Bio-priming, Disease management, Bio-control agent

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INTRODUCTION

Small millet crop have a long history of cultivation of more than 5000 years and grown in many part of the world because of its unique adaptation properties for marginal conditions of soil fertility, moisture and ability to tolerate abiotic stresses (Gowda *et al.,* 2006). Small millets are genetically diverse and grown where major cereals fail to produce satisfactory. Among small millets group, barnyard millet has emerged as very important feed as well as fodder crop. Barnyard millet grains are nutritious as similar to other millets.

However, productivity of the crop is reduced due to the number of factors *viz.,* non-availability of high yielding variety, quality seeds, diseases (Helimenthosporium leaf spot, grain smut, head smut, sheath blight) and insect pest attack. Among these factors, diseases alone cause 63.5 % reduction of grain yield as reported by (Kumar, 2013). The use of chemicals to control diseases in crops like barnyard millet seems to be uneconomical. However, these problems can be overcome by using bio-agents like *Pseudomonas fluorescens*, *Trichoderma harzarium*, *Aspergillus niger*, *Fusarium moniliforme*, because bio- agents having bio-control and plant growth promoting (PGP) activities may be a viable alternative to minimize use of synthetic chemicals and their hazardous effects, to provide protection to the plants against resident pathogen populations (Lugtenberg and Bloemberg, 2001).

Bio-agents can be applied as seed treatment, seed coating, seed priming and soil drenching, of which, most effective technique is seed priming because it may be used for reducing diseases, improvement of germination, vigour, seedling establishment and yield in crops (Talebian *et al*., 2008). Seed bio-priming is one of them which is a process of biological seed treatment that refers to a combination of seed hydration and seed inoculation with beneficial organisms to protect seed. The technique helps seeds to evenly germinate even under adverse soil conditions. Bio-priming could also reduce the amount of bio-control agents that must be applied to the seed (Rawat *et al.,* 2011 and 2012). Bio-priming is a seed treatment system that integrates the biological and physiological aspects of disease control, involves coating the seed with fungal or bacterial biocontrol agents. Furthermore, soil drench with *T. harzianum* has significantly reduced the incidence of seed borne diseases (Wilson and Jackson, 2013).

Therefore, more attention needs to be paid in exploiting bio-control agents by testing them *in-vitro* by applying artificial biotic and abiotic stresses as well as under heterogeneous field conditions, where such adverse conditions prevail. Considering the above facts, the present investigation on effect of seed bio-priming on morpho-physiological traits, disease management and seed quality of barnyard millet (*Echinochloa crusgalli* L.) was carried out to study the effect of seed bio-priming on plant growth parameters, seed yield, its contributing characters and against sheath blight and Helimenthosporium leaf spot diseases of barnyard millet.

MATERIAL AND METHODS

Seed material :

The seed material for the present investigation comprised one variety *viz.*, PRJ-1 of barnyard millet (*Echinochloa crusgalli* L.). The seed material was obtained from Plant Pathology Division, College of Forestry, Ranichauri, Tehri Garhwal, V.C.S.G. Uttarakhand University of Horticulture and Forestry, Uttarakhand.

Experimental details :

The treatments were comprised of ten different treatments including bio-agents, chemical fungicide and control. The different treatments used in the present field study are given in Table A.

Seed bio-priming :

Seeds were treated as per the treatments with respective bio-control agents @ 10g/kg seeds. Seeds were then kept under warm and moist conditions until prior to radical emergence.

Preparation of value added FYM (Colonization of FYM by bio-control agents) :

FYM before use was supplemented with bio-agents @ 250 g /q. 250 g of fresh bio-agents *viz.*, *Trichoderma* and *Pseudomonas* were mixed separately with 100 kg compost. Mixture was spread as approx. 6-10 inch layer under the shade and covered with leaves or rice straw. The supplemented FYM was left for 2 to 3 weeks. Water was sprinkled regularly just to maintain the moisture in the FYM heap. After 2 to 3 weeks this FYM colonized by bio-agent was ready for use as it contained very high population of bio-agents. This process increased the nutritive value of the FYM as well as provided opportunity to the bio-agents to grow faster on the FYM

Table A : Details of treatments used for field study

Sr. No.	Symbol	Treatments details	Dose
1.	T_1	Seed bio-priming with *Trichoderma asperellum Th*-14	@ 10g/kg seed
2.	T_2	Seed bio-priming with *Trichoderma harzianum Th*-21	@ 10g/kg seed
3.	T_3	Seed bio-priming with *Pseudomonas fluorescens Psf*-171	@ 10g/kg seed
4.	T_4	Seed bio-priming with *Pseudomonas fluorescens Psf*-4	@ 10/kg seed
5.	T_5	Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14	@ 10g/kg seed + 5-10 kg FYM/plot
6.	T_6	Seed bio-priming with *Trichoderma harzianum Th*-21+FYM colonized by *Th*-21	@ 10g/kg seed + 5-10 kg FYM/plot
7.	T_7	Seed bio-priming with *Pseudomonas fluorescens Psf*-171+FYM colonized by *Psf*-171	@ 10g/kg seed + 5-10 kg FYM/plot
8.	T_8	Seed bio-priming with *Pseudomonas fluorescens Psf*-4+FYM colonized by *Psf*-4	@ 10g/kg seed + 5-10 kg FYM/plot
9.	T_9	Seed treatment with carbendazim	@ 2 g/kg of seed
10.	T_{10}	Control	-

(Singh *et al.,* 2003).

Experimental design and layout :

The seeds were planted in Randomized Block Design (RBD) during *Kharif* season 2016 under rainfed conditions and different treatments were given as mentioned in Table A. Each treatment was sown in three replications. The plots were allocated randomized with different replications in block. The detail of experimental layout is given in Table B.

Seed sowing :

Seeds were sown in the field at about 3-4 cm depth by opening furrow with hoe. Each furrow was manually dribbled with seeds and covered with soil immediately. The row to row distance 22.5 cm and plant to plant distance 10.0 cm was maintained by thinning of extra plant population after 20 days of germination.

Observations recorded :

Number of leaves plant^{-1}:

The number of leaves was counted on five randomly selected plants from each plot. Leaves counts were recorded from the whole plant included tillers and their average values expressed as number of leaves plant^{-1}.

Stem diameter (mm) :

To measure the stem diameter, five plants were selected randomly from each plot and their stem diameter was recorded in millimeter with the help of vernier caliper.

Days to 50% flowering :

The numbers of days were taken from the date of sowing to the appearance of 50% flowering in the 50 per cent plants in each plot.

Plant height (cm) :

Plant height was measured at the time of physiological maturing. Height of five randomly selected plants was measured from the ground level to tip of the fully developed panicle.

Number of tillers plant^{-1} :

The number of tillers in each plant was counted by randomly selected five plants in every treatment at flowering stage.

Table B : Experimental layout is mentioned below

1.	Experimental Design		Randomized Block Design
2.	Crop		Barnyard millet (*Echinochloa crusgalli* L.)
3.	Name of variety		PRJ-1
4.	Number of treatments		Ten (10)
5.	Number of replications		Three (03)
6.	Plot size		2×2 m^2
7.	Spacing	Plant to plant	10.0 cm
		Row to row	22.5 cm
8.	Number of row/plot		Ten (10)
9.	Date of sowing		10-06-2016

Number of fingers ear^{-1} :

The number of fingers per plant was counted in five randomly selected plants from every treatment. Their fingers were counted and averaged to express the number of fingers per plant.

Ear length (cm) :

Five plants were selected randomly from each treatment and each replication and their length was recorded in centimeter with the help of meter scale.

Ear diameter (mm) :

Five ears were selected from each treatment and replication at the time of harvest maturity and their ear diameter were measured with the help of vernier caliper. The average was expressed as mean ear diameter.

Days to maturity :

It was recorded as the number of days taken from the date of sowing to harvest maturity in each treatment and replication (*i.e.* when 90% plants become straw colored and panicle were completely dry).

Biological yield plant^{-1} (g) :

Dry fodder yield was calculated at the time of harvesting in five randomly selected plants of each replication and the average termed as biological yield per plant.

1000 grain weight (g) :

1000 seeds were picked randomly from each treatments and weighed. The average value of 1000 seeds was expressed as 1000 seed weight.

Grain yield plant^{-1} (g) :

Five plants were randomly selected plants from each treatment and their seeds thrashed, winnowed and then weighed. The average value was used to express as seed yield per plant.

Grain yield (q/ha) :

The ear heads were harvested from each and every plant of each plot and their grain was threshed and winnowed. After that whole grain were weighed and expressed as grain yield.

Disease assessment :

Sheath blight and Helminthosporium leaf spot diseases of barnyard millet were monitored using SES scale (0-9 scale).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Plant growth and yield :

Results of plant growth promotion activities, yield and its contributing characters along with disease severity in barnyard millet after giving treatments are presented in Table 1 and 2. Field performance revealed that bio-control agents applied through two different methods *viz.*, seed bio-priming alone and seed biopriming along with colonized FYM, were found statistically superior to untreated control with respect to improving different planting value parameters, enhancing yield and reducing disease severity. The findings are described below in detail:

Days to 50 per cent flowering :

Significance influence of treatments was observed for days to 50 per cent flowering which ranged from 64.00 to 70.67 days with an overall mean of 66.93 days (Table 1). Minimum number of days (64.00 days) for 50 per cent flowering was taken by treatment T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14) followed by T_8 (64.33 days) and T_6 (65.33 days) which was at par with T_8 (64.33 days) while significantly maximum days (70.67 days) taken to 50 % flowering for T_{10} (control). NiranjanRaj *et al.* (2004) also reported significant difference for days to 50 per cent flowering in pearl millet and Anitha *et al.* (2015) in soybean.

Plant height (cm) :

Plant height significantly influenced by different treatments that ranged from 145.90 cm to 160.33 cm with an overall mean 151.12 cm (Table 1). Statistically maximum plant height (160.33 cm) was measured on T_5 (Seed bio-priming with *Trichoderma asperellumTh*-14+FYM colonized by *Th*-14) which was at par with T_8(158.40 cm), T_6(158.00 cm) and T_7 (157.7 cm). While, minimum plant height (145.90 cm) was measured on T_{10} (Control).

The enhancement in plant height might be due to rhizobacterial action of auxin production and phosphate

solubilization by tested bio-agents which played a role in better plant growth including plant height. Plant height is usually a good index of plant vigour which may contribute towards productivity. Similar results were reported by Niranjan Raj *et al.* (2004) in pearl millet and Hassan (2014) in rice.

Number of tillers plant^{-1}:

Extent of variability in tillers per plant might be due to production of phytohormones like auxin, cytokinin and gibberellins and also microbial inoculants would have provided more uptakes of nutrients from soil that might have helped in enhancing plant growth. A perusal of mean data (Table 1) indicated that number of tillers per plant ranged from 3.33 to 6.00with an overall mean of 4.67. The highest value (6.00) for number of tillers per plant was observed on the treatment T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14) which was almost at par with T_8 (5.67) and T_6 (5.33) while, minimum tillers per plant was recorded in control (3.33). Abdullahi *et al.* (2014) also reported significant difference for number of tillers per plant in pearl millet, Niranjan Raj *et al.* (2004) again in pearl millet and Gangwar and Sinha (2014) in rice.

Number of leaves plant^{-1} :

The mean value for the number of leaves plant^{-1} ranged from 9.87 to 12.13 with an overall mean of 10.69 plant^{-1} (Table 1).The maximum number of leaves plant^{-1} (12.13) was counted in treatment T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14) which was at par with T_8 (11.90), T_6 (10.94) and T_7 (10.73) treatments. While, minimum numbers of leaves plant^{-1} (9.87) was counted in T_{10} (control) followed by T_9 (10.40), T_1 (10.37) and T_4 (10.33). The results are in accordance with the work of Miranda (2012) in wheat.

Ear diameter (mm) :

The mean value for the ear diameter (Table 1) revealed significant variation for this character among different treatments given to barnyard millet under study. The mean values for ear diameter ranged from 46.62 mm to 59.55 mm with an overall mean of 52.74 mm. Maximum mean value (59.55 mm) recorded for T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14 + FYM colonized by *Th*-14) treatment which was at par with T_8 (58.47 mm) and T_6(56.55 mm). While minimum ear diameter (46.62 mm) was recorded for T_{10} (control) followed by T_3 (48.64 mm). Similar significant findings for ear diameters have earlier also been reported by Niranjan Raj *et al.* (2004) in pearl millet.

Stem diameter (mm) :

The mean value for the stem diameter revealed significant variation among treatments that ranged from 8.96 mm to 10.42 mm with overall average 9.86 mm (Table 1). Highest stem diameter (10.42 mm) was recorded in the treatment T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14) followed by treatment T_8 (10.23 mm) and treatment T_6 (10.18 mm). Minimum stem diameter (8.96 mm) was recorded by T_{10} (control) which was at par with the

Table 1 : Effect of bio-priming and colonized FYM with bio-control agents on plant growth traits of barnyard millet

Sr. No.	Treatments	Days to 50% flowering	Plant height (cm)	Number of tillers per plant	Number of leaves/plant	Ear diameter (mm)	Stem diameter (mm)	Ear length (cm)
1.	T_1	67.33	148.30	4.67	10.37	50.37	9.79	18.47
2.	T_2	68.33	147.33	4.00	10.20	49.89	9.72	18.20
3.	T_3	69.00	148.10	3.67	10.00	48.64	9.65	18.17
4.	T_4	68.00	146.77	4.33	10.33	50.35	9.77	18.33
5.	T_5	64.00	160.33	6.00	12.13	59.55	10.42	19.73
6.	T_6	65.33	158.00	5.33	10.94	56.55	10.18	19.43
7.	T_7	65.67	157.57	5.00	10.73	53.89	10.09	19.30
8.	T_8	64.33	158.40	5.67	11.90	58.47	10.23	19.67
9.	T_9	66.67	148.37	4.67	10.40	53.08	9.81	18.53
10.	T_{10}	70.67	145.90	3.33	9.87	46.62	8.96	17.80
GM		66.93	151.12	4.67	10.69	52.74	9.86	18.76
S.E. ±		0.390	3.270	0.322	0.485	1.019	0.245	0.182
L.S.D. (5%)		1.167	10.819	0.964	1.442	3.029	0.734	0.927
CV (%)		1.008	4.152	11.952	7.865	3.348	4.304	2.886

treatments T_8 (10.23 mm), T_6 (10.18 mm) and T_7 (10.09 mm). The increase in stem diameter might be resulted due to plant growth promotion activities created by used microbial inoculants, as earlier reported by Rawat *et al.* (2011). Similar results were also observed by Prasad *et al.* (2009) and Hassan (2014) in rice.

Ear length (cm) :

Ear length influenced significantly which varied from 17.80 cm to 19.73 cm with an overall mean 18.76 cm (Table 1). Maximum ear length (19.73 cm) was measured in T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14) which was almost at par with T_8 (19.67 cm), T_6 (19.43 cm) and T_7 (19.30 cm) while, significantly lowest ear length (17.80 cm) was measured by T_{10} (control) which was at par with T_9 (18.53 cm), T_1 (18.47 cm) and T_4 (18.33 cm). 55.7 per cent enhancement in ear length was recorded over control when seeds were treated with treatment T_5. These findings are in close conformity with the findings of Niranjan Raj *et al.* (2004) in pearl millet and Prasad *et al.* (2009) in wheat and Hassan (2014) in rice.

Seed yield and its contributing characters :

Number of finger ear^{-1}:

Number of fingers ear^{-1} is principle yield contributing trait that was influenced significantly by different treatments (Table 2). Number of fingers ear^{-1} ranged from 28.47 to 33.73 with the general mean of 30.87 ear^{-1}. The maximum number of fingers ear^{-1} (33.73) was recorded in T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14) followed by T_8 (32.60) and T_6 (31.93). Minimum number of fingers ear^{-1} (28.47) was recorded in T_{10} (control) which was at par with T_1 (31.07), T_9 (30.73) and T_4 (30.27).

The increase in the number of fingers may be attributed due to the synthesis of amino acid and chlorophyll and better carbohydrates transformation which resulted in better growth and a higher number of fingers which ultimately produced more number of grains per finger. Similar results were also reported by Niranjan Raj *et al.* (2004) in finger millet.

Days to maturity :

Days to maturity varied from 109.00 to 125.00 days with an overall mean 114.43 days (Table 2). Lowest days to maturity (109.00 days) was recorded in T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14) followed by T_8 (110.67 days) and T_6 (111.67 days) which was found significantly superior over other treatments while, maximum days (125.00) was taken to days to maturity in T_{10} (control). Similar finding was also reported by Kumar (2013) in barnyard millet.

Biological yield plant^{-1} (g) :

Highly significant difference observed among all the treatments with respect to biological yield plant^{-1}. Biological yield plant^{-1} was ranged from 43.23 g to 57.65 g with an overall mean of 51.28 g plant^{-1} (Table 2). The maximum biological yield plant^{-1} (57.65 g) was recorded in T_5 (*Th*-14 + FYM colonized by *Th*-14) followed by T_8 (56.45 g) and T_6 (54.45 g) while, minimum biological

Table 2 : Effect of bio-priming and colonized FYM with bio-control agents on yield and its contributing traits of barnyard millet

Sr. No.	Treatments	Number of fingers per ear	Days to maturity	Biological yield per plant (g)	1000 grain weight (g)	Grain yield per plant (g)	Grain yield (q/hac)
1.	T_1	31.07	114.67	51.02	4.42	33.21	15.48
2.	T_2	29.27	116.00	48.88	4.23	32.05	15.00
3.	T_3	29.07	116.33	46.12	4.13	31.82	14.25
4.	T_4	30.27	115.67	50.19	4.22	32.70	15.17
5.	T_5	33.73	109.00	57.65	4.91	35.49	19.17
6.	T_6	31.93	111.67	54.45	4.75	34.81	17.42
7.	T_7	31.53	112.33	53.64	4.60	34.53	17.17
8.	T_8	32.60	110.67	56.45	4.87	35.05	18.25
9.	T_9	30.73	113.00	51.240	4.47	33.62	16.68
10.	T_{10}	28.47	125.00	43.23	4.12	30.91	13.92
	GM	30.87	114.43	51.288	4.47	33.42	16.24
	S.E. ±	0.880	2.694	2.359	0.219	0.542	0.672
	L.S.D. (5%)	2.636	8.067	7.063	N/A	1.624	2.013
	CV (%)	4.941	4.078	7.966	8.472	2.81	7.17

yield plant^{-1} (43.23 g) recorded in T_{10} (Control). This finding is in close conformity with the finding of Mishra *et al.* (2014). Hassan (2014) also reported 4.12 q/ha to 7.54 q/ha biological yield in wheat with biological treatments.

1000 grain weight (g) :

Seed weight is the most important qualitative as well as quantitative parameter that directly affects the seed yield and quality of the seed lot. In the present study, 1000 seed weight (g) ranged from 4.12 g to 4.91 g with an overall mean of 4.47 g (Table 2). Maximum 1000-seed weight (4.91 g) was recorded in T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14) followed by T_8 (4.87 g) and T_6(4.75 g) while, minimum (4.12 g) was recorded in T_{10}(control).

The response of bio-control agents on seed weight is well known and similar results on response of bio-priming on seed weight has been reported by Niranjan Raj *et al.* (2004) in pearl millet that ranged from 5.6 g to 6.8 g. Whereas Prasad *et al.* (2009) reported 1000 seed weight ranged from 37.89 g to 43.97g in wheat.

Grain yield plant^{-1}(g) :

Statistically significant differences were recorded in grain yield per plant among all the treatments (Table 2), that ranged from 30.91 g to 35.49 g with an overall mean of 33.42 g. Among all the treatments, T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by Th-14) showed highest grain yield (35.49 g) plant^{-1} which is at par with T_8 (35.05 g), T_6 (34.81 g) and T_7 (34.53 g) while; minimum was recorded in control (30.91 g). A wide range of variability in grain yield plant^{-1} was reported by Gangwar and Sinha (2014) in rice. Anitha *et al.* (2015) reported the grain yield ranged from 13.20 to 31.20 g plant^{-1} in soybean.

Grain yield (q/ha) :

Grain yield is the major determinant variable for selecting a particular crop for its commercialization and income generation capability. Significant differences were observed for grain yield which ranged from 13.92 to 19.17 q/ha with an overall general mean of 16.24 q/ha (Table 2). Maximum grain yield (19.17 q/ha) was recorded in the treatment T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14) followed by T_8 (18.25 q/ha) and T_6 (17.42 q/ha) which were significantly at par with each other. Minimum grain yield (13.92 q/ha) was recorded in T_{10} (control) followed by the treatments T_3 (14.25 q/ha) and T_2 (15.00 q/ha).

The 27.39 per cent grain yield enhancement was recorded when seeds primed by *Trichoderma asperellum Th*-14 and FYM colonized by *Th*-14 applied in the soil over control. The increase in grain yield might be due to positive influence of bio-agent in initiation and growth of roots that in turn speed up and increased the uptake of essential elements and moisture from the soil. Similar results was also reported by Niranjan Raj *et al.* (2004) in pearl millet, Prasad *et al.* (2009) in wheat and Kumar (2013) in barnyard millet.

Disease assessment :

Incidence of sheath blight (%) :

The data revealed that all the treatments are able to reduce the disease significantly over control (Fig. 1). Minimum disease incidence (0.00 %) of sheath blight was observed in the treatment T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14) followed by T_8 (2.33 %) and T_6(3.67%) while, maximum disease incidence (28.67 %) was recorded in T_{10}(control) followed by T_3(18.33 %) and T_2(14.67 %).

Based on the present studies, it can be suggested that the treatment T_5 (Seed bio-priming with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14) has improved the disease inhibition followed by other treatments and can be effectively exploited for the management of sheath blight disease in barnyard millet. Similar findings were also reported by Neha *et al.* (2016) by recording minimum incidence of sheath blight disease in rice that ranged from 13.33 to 53.67 per cent. Jayaprakashvel *et al.* (2014) reported that the sheath blight in rice ranged from 0.00 to 83.30 per cent after

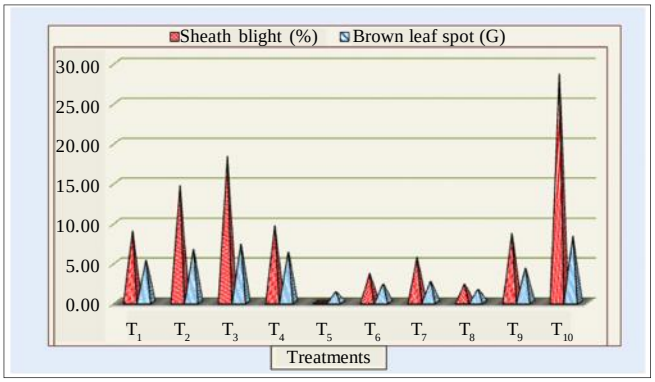

Fig. 1 : Effect of bio-priming and colonized FYM with bio-control agents on major diseases of barnyard millets (Var. PRJ 1)

giving biological seed treatment.

Incidence of brown leaf spot (%) :

A visual assessment of treatments indicated a noticeable difference in disease incidence when compared to the untreated control (Fig. 1). Significantly minimum incidence of brown leaf spotdisease (1.33 G) was observed when seed primed with *Trichoderma asperellum Th*-14+FYM colonized by *Th*-14 (T_5) which was at par with T_8(1.67 G) and T_6 (2.33 G) whereas, maximum disease incidence (8.33 G) was recorded in untreated control (T_{10}) followed by T_3 (7.33 G) and T_2 (6.67 G).

The results are supported by earlier reports of Wani (2015) who evaluated *Trichoderna* strain against the leaf blight disease in maize with minimum disease incidence (5.40 %). Srivastava and Shalini (2008) evaluated different strains of *Pseudomonas fluorescens* which inhibited the growth of *Helminthosporium* spp., and Turaki (2007) recorded minimum disease incidence percentage (10.4 %) in foxtail millet pre-inoculated with *Trichoderma* strain.

Conclusion :

Based on the results of the present experiments, it may be concluded that the bio-agents had significant influence on plant growth, seed yield, and its contributing characters along with management of important diseases of barnyard millet than fungicide. Inoculation of *Trichoderma asperellum*as seed treatment and colonized farmyard manure application is responsible for enhancing morpho-physiological growth, nutrient uptake from soil and provide resistance against seed borne as well as soil borne pathogens. Among studied bio-agents, *Trichoderma* strains play an important role in the bio-remediation of soil that is contaminated with pesticides and herbicides. Therefore, *Trichoderma asperellum Th*-14 were recommended for barnyard millet seeds treatment and colonized farmyard manure in Uttarakhand hills for obtaining maximum yield per unit area.

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