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Integration of Seed Biopriming, Soil and Foliar Application of Formulations of *Trichoderma* Species for Growth Promotion of Sorghum under Field Condition

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A B S T R A C T

Seed biopriming, soil application with enriched FYM and foliar application of talc based formulation of *Trichoderma* isolates were evaluated under field condition during the Kharif season 2015. Integration of seed biopriming, soil application enriched FYM and foliar application of *Trichoderma* isolates T3 and T19 was found highly effective in promoting root and shoot length and stem diameter of sorghum. Individually, soil application and biopriming of seed with *Trichoderma* isolates were effective in growth promotion activity but their effectiveness was greater when applied as a combination. Thus, combined application of the formulations is recommended for the growth promotion activity in sorghum crop.

Introduction

Sorghum is grown in more than 90 countries and ranked as 5th most important cereal crop worldwide. It is a staple food in Africa and provides diet for 500 millions of people. Sorghum is used as fodder crop to feed the cattle as well as used for industrial purposes. Although Sorghum can tolerate adverse conditions but its yield as well as overall plant health is hampered by abiotic and biotic stresses (Chala *et al.*, 2011). *Trichoderma* has been used as biocontrol agent against many phytopathogenic fungi and *Trichoderma* spp are also reported to promote plant health by improving overall plant growth aside from the direct inhibition of plant pathogens (Abdel-Fattah *et al.*, 2007).

The present work was planned to assess the abilities of *Trichoderma* isolates as well as to check the efficiency of combined application

of the formulation for the growth promotion of sorghum under field conditions.

Materials and Methods

Isolates of T3, T4, T15 and T19 of *Trichoderma asperallum* and T6 isolate of *Trichoderma harzianum* isolated from sorghum rhizosphere of Uttarakhand were used for field evaluation.

Field Trials

The field experiment was conducted in Randomized block design with five replications in Kharif Season 2015. Susceptible Sorghum cultivar PC-23 was planted at sorghum pathology block, Livestock Research Centre, GBPUA&T for evaluation of effectiveness of growth promoting activity of *Trichoderma* isolates.

Seed biopriming

Seed were presoaked in water for 24 hrs. Presoaked seeds were treated with talc based product of *Trichoderma* having 10^8cfu/g @10g/kg of seeds in 2% gum arabic solution. The seed were incubated for 48h at 25-28°C.*Trichoderma* isolates adhered on the seed; grow on the seed surface to form a protective layer all around the seed coat under moist condition. The observation regarding root length, shoot length and stem diameter were recorded after 90DAS.

Soil application

For the soil application the 20kg of talc based formulation of *T. asperallum* and *T. harzianum* isolates was mixed with 200kg of well-rotted Farm yard manure in a pit and covered for 10 days by polythene sheet. The mixture was turned every 3 days regularly. When *Trichoderma* mycelium proliferated throughout the FYM then on 10th of day pit was opened and mixture was turned well and spread in the field plots one week before sowing.

Foliar spray

Foliar spray of talc based formulation *Trichoderma* isolates @ 10g/lit of water was given after 30 DAS.

Results and Discussion

Effect of biopriming of seed with different isolates of *Trichoderma* on growth promotion of sorghum

The data presented in table 1, shows the effect of biopriming of seed with different isolates of *Trichoderma* on root length, shoot length and stem diameter of sorghum plants.

Root length

The data shows that after 90DAS, significant increase in root length was recorded in biopriming of seed with different *Trichoderma* isolates viz: T3, T19, T4, T6, and T15 as compared to control. Among the treatments, the highest root length was recorded in T3 isolate (44.254cm) however, T19 (44.080cm) was at par with T3 followed by T4 (40.974cm) isolate whereas least growth was observed in untreated control (36.288cm).

Shoot length

The data shows that after 90DAS, seed biopriming with different *Trichoderma* isolates viz: T3, T19, T4, T6, and T15 significantly increased the shoot length as compared to control. The highest shoot length was recorded in T3 isolate (293.000cm) followed by T19 isolate (287.000cm) however which T4 (285.200cm) and T6 (281.000cm) isolate was statistically at par

with T19, whereas least growth was observed in untreated control (253.000cm).

Stem diameter

Seed biopriming with different isolates of *Trichoderma* significantly increased the stem diameter. Highest stem diameter was observed in T3 isolate (2.030cm) however, T19 isolate (1.958cm) was statistically at par with T3, followed by T4 isolate (1.818cm) and least growth was observed in untreated control (1.476cm).

Our results are similar to that reported by Yadav *et al.,* (2013) who concluded that seed biopriming enhanced germination percentage and increased plant growth as compared to non-primed control plants. Seed biopriming reduces the amount of biocontrol agent that is used for biopriming than seed coating or seed treatment. Seed biopriming also enhanced the uniform and rapid seedling emergence. The bioprimed seed tolerate the adverse soil conditions and promote the plant growth (Mathre *et al.,* 1999). Biopriming of seed enhanced the seedling growth and reduced the incidence of seed and soil borne diseases (Zaidi *et al.,* 2004).

Mastauri *et al.,* (2010) concluded that biopriming of seed with biocontrol agents enhanced the plant vigour and seed germination percentage of sorghum seeds than untreated sorghum seed. Seed biopriming with formulation of *Trichoderma* significantly increased the plant growth promotion (Singh and Nautiyal, 2012). Ousley *et al.,* (1994) reported similar finding in petunia plants where they observed that the application of *T. harzianum* strain TH1 applied at a rate of 0.1% w/v significantly increased the root and shoot length as compared to control. Harman *et al.,* (2000) observed that biopriming of seed with strain T22 (*T.harzianum*) significantly increased the root and shoot length of maize under field and glass house conditions.

Effect of soil application of *Trichoderma* isolates enriched FYM on growth promotion activity of Sorghum

The data presented in table 2, shows that soil application of *Trichoderma* isolates T3, T19, T4, T6, and T15 enriched FYM significantly increased the root length, shoot length and stem diameter of sorghum plants as compared to control after 90DAS.

Root length

Maximum root length was recorded in T3 isolate (42.904cm) which was statistically at par with T19 isolate (42.092cm) followed by T4 isolate (40.886cm) isolate whereas least root length was found in untreated control (36.288cm).

Shoot length

Maximum shoot length was observed in T3 (280.400cm) isolate however T19 (279.600cm) isolate was statistically at par with T3 isolate followed by T4 (271.000cm) isolate whereas least shoot length was found in untreated control (253.000cm).

Stem diameter

Highest stem diameter was observed in T19 (1.838cm) isolate however, T3 (1.752cm) isolate was statistically at par with T19 followed by T4 (1.572cm) isolate whereas least shoot length was found T6 isolate (1.334cm).

Soil application of *Trichoderma viride* and *Trichoderma harzianum* enriched FYM one week before sowing of seed was more effective in reducing the wilt and root rot of chickpea and enhanced the plant growth.

Table.1 Effect of biopriming of seed with different isolates of *Trichoderma* on growth promotion of sorghum

Treatments	Root length (cm)	Shoot length (cm)	Stem diameter (cm)
T3	44.254±1.716^{a}	293.000±5.385^{a}	2.030±0.036^{a}
T4	40.974±0.912b^{ab}	285.200±7.003^{ab}	1.818±0.031^{b}
T6	40.526±0.866^{b}	281.000±6.782^{ab}	1.768±0.036^{b}
T15(A)	39.186±0.859^{bc}	273.000±5.385^{b}	1.620±0.031^{c}
T19(B)	44.080±1.263^{a}	287.000±3.742^{ab}	1.958±0.038^{a}
Control	36.288±0.889^{c}	253.000±4.899^{c}	1.476±0.059^{d}
CD at 5%	1.713	7.244	0.089
C.V.	3.153	1.957	3.770
SE(m)	0.577	2.439	0.030
Values given in column are the average of five replications. Values with different alphabetical (a–d) superscripts within a column are significantly different ($P \leq 0.05$) using Duncan's multiple range tests (DMRT).			

Table.2 Effect of soil application of *Trichoderma* isolates enriched FYM on growth promotion of Sorghum

Treatment	Root length (cm)	Shoot length (cm)	Stem diameter (cm)
T3	42.904±0.859^{a}	280.400±4.285^{a}	1.752±0.034^{a}
T4	40.886±0.688^{bc}	271.000±2.793^{ab}	1.572±0.036^{b}
T6	39.294±0.312^{cd}	266.400±4.750^{ab}	1.334±0.038^{c}
T15	37.962±0.485^{d}	261.800±6.061^{b}	1.394±0.044^{c}
T19	42.092±0.452^{ab}	279.600±4.226^{a}	1.838±0.018^{a}
Control	36.288±0.889^{d}	253.000±4.899^{c}	1.476±0.059^{ab}
C.D. at 5%	1.575	8.826	0.106
SE(m)	0.530	2.971	0.036
C.V.	2.971	2.472	5.125
Values given in column are the average of five replications. Values with different alphabetical (a–d) superscripts within a column are significantly different ($P \leq 0.05$) using Duncan's multiple range tests (DMRT).			

Table.3 Effect of seed bioprimimg + soil application + foliar spraying with *Trichoderma* isolates on growth promotion of sorghum

Treatment	Root length (cm)	Shoot length (cm)	Stem diameter (cm)
T3	53.124±0.337[a]	324.8±3.338[a]	2.172±0.032[a]
T4	50.852±0.580[b]	306.8±3.891[b]	1.658±0.026[b]
T6	50.460±0.455[b]	304.0±1.817[b]	1.636±0.028[b]
T15	50.730±0.546[b]	305.0±2.881[b]	1.712±0.009[b]
T19	53.248±0.264[a]	326.2±2.059[a]	2.106±0.035[a]
Control	36.288±0.889[c]	253.000±4.899[c]	1.476±0.059[c]
C.D.at5%	1.465	10.241	0.106
SE(m)	0.493	3.447	0.036
C.V.	2.244	2.541	4.433

Values given in column are the average of five replications. Values with different alphabetical (a–c) superscripts within a column are significantly different ($P \leq 0.05$) using Duncan's multiple range tests (DMRT).

Enhancement in the *Trichoderma* population, played a positive role in increasing the uptake of nutrients from the rhizospheric zone that ultimately enhanced the plant growth promotion after the soil application of *Trichoderma* enriched FYM has been reported in Maize (Bjurkman *et al.*,1994), tomato (Ozbay *et al.*, 2004), pea (Naseby *et al.*, 2000) and cucumber (Kleifield and Chet, 1992). Maximum rhizospheric colonization and growth promotion was recorded in terms of number of tillers, rootlets, root and shoot length and number of grain per spike in wheat crop after the soil application of *Trichoderma harzianum* enriched FYM (Sharma *et al.*, 2012). Soil application of *Trichoderma* enriched FYM was effective in controlling the seed borne pathogenic fungi *R. solani*, *F. moniliforme*, *F. oxysporum*, *F. solani*, *A. alternata* and *B. theobromae* (Mustafa, 2009).

The soil application of mustard strains of *Trichoderma* T17 enriched FYM along with seed treatment recorded the maximum root and shoot length, maximum fresh weight of shoot and root of sunflower compared to control in addition to zero incidence of charcoal rot (Nagmani *et al.*, 2011).

Effect of seed bioprimimg + soil application + foliar spraying with *Trichoderma* isolates on growth promotion of sorghum

The data presented in table 3, shows the additive effect of biopriming of seed with different isolates of *Trichoderma* + soil application of *Trichoderma* isolates enriched FYM + foliar spraying with different isolates of *Trichoderma* significantly increased in on root length, shoot length and stem diameter of sorghum plants as compared to control

Root length

Maximum root length was recorded in T19 isolate (53.248cm) however, T3 isolate (53.124cm) was statistically at par with T19 followed by T4 (50.852cm) whereas least shoot length was found in untreated control (36.288cm).

Shoot length

Maximum shoot length was recorded in T19 isolate (326.200cm) however, T3 isolate (324.800cm) was statistically at par with T19 followed by T4 (306.800cm) whereas least

shoot length was found in untreated control (253.000cm).

Stem diameter

Maximum stem diameter was recorded in T3 isolate (2.172cm) however, T19 isolate (2.106cm) was statistically at par with T3 followed by T15 (1.712cm) whereas least shoot length was found in untreated control (1.476cm).

The present study results are similar to that reported by Meena *et al.,* (2008) on effect of foliar spray and biopriming of seed with *Pseudomonas* and *Trichoderma* on disease severity and plant growth against anthracnose of sorghum. Maximum increase in root length, shoot length and stem diameter and significant reduction in disease severity was observed. Singh and Singh (2008) also reported the effect of biopriming of seed and foliar spraying of *Trichoderma harzianum* isolates decreased the disease severity and increased overall plant growth and yield of sorghum. The combined effect of seed treatment and soil application with *Trichoderma* enriched FYM increased the root and shoot length and significantly reduced the wet root rot incidence in Chick pea as compared to control (Jambhulkar, 2015). The combination of soil application with PBP16G (*Trichoderma viride*) and seed treatment with Pusa 5SD (*Trichoderma virens*) showed the highest seed germination, root and shoot length and reduced wet root rot incidence in mung bean compared with any individual treatment (Dubey *et al.,* 2011). The combination of seed treatment with Pusa 5SD (*Trichoderma harzianum*) and soil application with PBP4G (*Trichoderma viride*) plus carboxin increased the seed germination, root and shoot length and grain yield of chickpea and also reducing the *Fusarium* wilt incidence in chickpea rather than individual use of any treatment (Dubey *et al.,* 2013). Jayalaxmi *et al.*, (2013) conducted the study and concluded that combination of soil application of neem cake plus seed treatment plus soil application of *Trichoderma viride* followed by foliar spray of azadirachtin was found to increase the yield, host growth and reducing the diseases of sesame.

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