Efficacy of *Trichoderma harzianum* and AM fungi on ber (*Ziziphus mauritiana* Lamk.) cv. Seo based agri-horti system in central India

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ABSTRACT : Present study was conducted in four years-old well established ber based agri-horti system in central India aiming to assess whether use of chemical fertilizer can be reduced with the help of incorporating bio-inoculants (*Trichoderma harzianum* and AM fungi). The experiment comprised of ten treatments *viz.,* T1- ber (100% recommended dose of fertilizer (RDF)), T2- ber (100% RDF) + sesame-lentil, T3- ber (75% RDF), T4- ber (75% RDF) + sesame-lentil, T5- ber (75% RDF) + AM fungi, T6- ber (75% RDF) + AM fungi + sesame-lentil, T7- ber (75% RDF) + *T. harzianum,* T8- ber (75% RDF) + *T. harzianum* + sesame-lentil, T9- ber (75% RDF) + AM fungi + *T. harzianum* + sesame-lentil and T10- sesame-lentil. Ber plants were planted in randomized block design with three replications having six plants in each treatment at the spacing of 6×8 m. The variations in observations recorded on different characters (plant growth, pruned material and fruit) of ber were found non-significant, except fresh pruned material (kg $plant^{-1}$), number of fruits and fruit yield (kg $plant^{-1}$), and found significantly higher in treatment T7, T1 and T8, respectively in the year 2014-15 whereas during 2015-16, different plant growth and fruit traits were influenced significantly, except canopy spread and pulp/stone ratio. In most of the cases, T8 was found significantly higher. Observations on sesame and lentil revealed that the T10 and T6 recorded highest seed yield during both the years and was significantly higher with respect to other treatments. Maximum land equivalent ratio was recorded in T8 during both the years. Soil analysis revealed that all the treatments had better soil test values than control at 0-15 and 15-30 cm soil depth. The treatments containing AM fungi and *Trichoderma* have shown pronounced effect on available phosphorus. Conclusively, use of *Trichoderma* has shown potential to save 25% chemical fertilizer for achieving attractive yield in ber based agri-horti system thus reducing cost of fruit production and protecting health of consumer.

Key words: Bundelkhand, ber fruit, land equivalent ratio, lentil, soil properties and sesame.

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1. INTRODUCTION

Bio-inoculants are cost effective and eco-friendly natural inputs providing alternate source of plant nutrients, and increase farm income by providing extra yield and reducing input costs. Bio-inoculants are reported to increase crop yield by 20-30%, replace nitrogen (N) and phosphorus (P) by 25% (Thakur *et al.*, 2016), stimulate plant growth, activate soil biological activity, restore natural fertility and provide protection against drought and some soil-borne diseases. The principal aim of agriculture is the production of high quality, safe and affordable food for an ever-increasing population. Furthermore, agricultural growers and producers have the additional constraints of economic profitability and sustainability. With the increasing problems associated with the use of synthetic chemicals in agriculture (impacts on health and the environment, resistance development in plant pathogens and pests etc.), there has been an increasing interest in the use of native and non-native beneficial microorganisms to improve plant health and productivity while ensuring safety for human consumption and protection of the environment. In this context, many soil-borne microorganisms have been assessed over the years and are now integrated into a wide variety of growing systems as part of integrated pest and productivity management practices (Antoun and Prevost, 2005).

Trichoderma strains are able to promote root development, increase efficiency of fertilizer utilization, improve rhizosphere environment, and enhance plant resistance to disease and augment minor nutrient uptake by plants. The application of *Trichoderma* species has not only an antagonistic effect on plant pathogens but also has positive effect on plant growth and yield. The increased growth response is mainly due to mineral solubilisation and uptake of minor and other minerals as well as improvement in the root morphology enabling the roots to exploit a large volume of soil (Altomare *et al.*, 1999; Elad and Kapat, 1999).

Arbuscular mycorrhizal (AM) fungi are ubiquitous in nature and represent the oldest and most widespread symbiosis with land plants thereby constituting a vital component of terrestrial ecosystems including horticulture and agro-based ecosystems. The primary effect of AM fungi on the host plant is an increase in nutrients uptake and plant growth (Kumar *et al.*, 2017). Plants with mycorrhiza are potentially more effective in nutrient and water uptake (Shukla *et al.*, 2010) and less susceptible to diseases (Shukla *et al.*, 2014). They can increase uptake of nutrients especially which are relatively immobile in the soil such as P and consequently increase plant biomass and growth (Jha *et al.*, 2014). AM fungi improve nutrient cycling and soil quality by formation of soil aggregates thus controlling soil erosion by a better plant rooting capacity. It influences plant biodiversity, protect against pests and diseases, increase plant establishment and survival at seeding or transplanting, enhance flowering and fruiting, increase crop yield and quality, improve tolerance to drought and soil salinity, and improve the growth of plants in nutrient deficient soils or polluted environments (Shukla *et al.*, 2014).

Keeping in view the beneficial effects of *Trichoderma* and AM fungi, present study was conducted for enhanced system productivity, profitability and sustainability of ber (*Ziziphus mauritiana Lamk.*) cv. Seo based agri-horti system under semi-arid conditions of Bundelkhand region. The main aim was to assess whether doses of chemical fertilizer can be curtailed by incorporating the bio-inoculants (*Trichoderma harzianum* and AM fungi), without compromising the production and quality of produce.

2. MATERIALS AND METHODS

A study was conducted in an established four years-old ber based agri-horti system at ICAR-CAFRI, Jhansi during 2014-15 and 2015-16. The study comprised of ten treatments *viz.,* T1- ber (100% recommended dose of fertilizer (RDF)), T2- ber (100% RDF) + sesame-lentil, T3- ber (75% RDF), T4- ber (75% RDF) + sesame-lentil, T5- ber (75% RDF) + AM fungi, T6- ber (75% RDF) + AM fungi + sesame-lentil, T7- ber (75% RDF) + *T. harzianum,* T8- ber (75% RDF) + *T. harzianum* + sesame-lentil, T9- ber (75% RDF) + AM fungi + *T. harzianum* + sesame-lentil and T10- sesame-lentil, which were imposed before the onset of monsoon by adopting randomized block design with three replications having six plants in each treatment at the spacing of 6×8 m. The observations were recorded on plant growth characters, fruit characters and yield components, and analyzed by adopting SPSS software version 11.5.

As per the treatments, required quantity of chemical fertilizers was applied in channels digged out 30 cm 110 away around tree trunk and covered with soil. During 2014-15 the RDF was 30 kg FYM, 200 g N, 100 g P and 100 g K; whereas, in 2015-16, it was 30 kg FYM, 250 g N, 125 g P and 125 g K plant^{-1}. *Trichoderma* (talcum powder formulation) was procured from ICAR-Indian Institute of Pulses Research, Kanpur having spore density 5×10^{6} cfu g^{-1}. Before applying to ber plants, it was mixed with FYM @ 110 g formulation (approximately) per tree and kept for ten days by covering polythene sheet. During this period, FYM was kept moist and turned twice upside down. After ten days, it was mixed in tree basin. In present study, consortium of two AM fungi (1:1 ratio, w/w), namely *Glomus intraradices* and *Acaulospora scrobiculata* served as inoculum. Both the species are commonly occurring in the region and their purified cultures are being maintained in sterilized sand on *Zea mays* L. under net-house conditions at the institute. The consortium used in our study consisted of sand along with chopped root bits, spores and extrametrical mycelium from culture pots. For the application of AM fungi, consortium was diluted two times with sand and applied in tree basins.

Lentil (var. DPL-62) sown during November, 2014 and 2015 (*rabi*) was harvested during March, 2015 and 2016; whereas, sesame (var. G-1) was sown during July, 2015 and 2016 (*kharif*) and harvested during October, 2015 and 2016. Both the crops were sown by adopting recommended cultural practices; however, lentil was grown on residual fertility. All the yield contributing parameters for each crop were recorded and analyzed statistically using SPSS software version 11.5.

The land equivalent ratio (LER) was calculated using the formula LER = Σ (Ypi/Ymi), where Yp is the yield of each crop or variety in the intercrop or poly culture and Ym is the yield of each crop or variety in the sole crop or monoculture. The LER value of 1.0 indicates no difference in yield between the intercrop and the cultivation of monocultures. Any value greater than 1.0 indicates a yield advantage for intercrop. A total LER of higher than 1.0 indicates the presence of positive interferences among varieties or crop components of the mixture, and also means that any negative inter-specific interference that exists in the mixture is not as intensive as the intra-specific interference that exists in the monocultures. For each crop, a ratio was calculated to determine the partial LER for that crop, and then the partial LERs were summed up to get total LER for the intercrop (Dariush *et al.*, 2006, Nimbolkar *et al.*, 2016).

Geographically Jhansi is located at 25^0 27' N and 78^0 35' E at an altitude of 271 m above mean sea level and having semi-arid and sub-tropical climate with extremely hot summer. There is a gradual increase in daily temperature from April to May. The average rainfall of this region is 900 mm, maximum mean temperature 32.5 ^{0}C (48 ^{0}C in the month of May) and minimum mean temperature 17.7 ^{0}C (1.5 ^{0}C in the month of January). The soil of experimental plot is mixture of red and black, and its chemical properties at 0-15 cm soil depth were : pH: 6.64-7.53; electrical conductivity (EC): 108-240 uS m^{-1}; organic carbon: 0.42-0.79%; dehydrogenase activity: 119.01-160.66 ug TPF g^{-1} d^{-1}; and available N: 204.0-296.3 kg ha^{-1}; while at 15-30 cm depth, values were : pH: 6.73-7.38; EC: 58.3-185.7 uS m^{-1}; organic carbon: 0.35-0.52%; dehydrogenase activity: 84.2-131.8 ug TPF g^{-1} d^{-1}; and available N: 148.5-180.0 kg ha^{-1}.

After experimental period, treatment-wise soil samples were collected from 0-15 and 15-30 cm soil depth from tree basin (50 cm away from the main stem), to assess the effect of different treatments on soil characteristics. After processing the soil samples in laboratory, soil pH and EC were determined at 1:2.5 soil–water ratio by using pH tester (Waterproof pH Tester 30; Eutech Instruments; Thermo Scientific) and EC tester (Waterproof EC Tester 11+; Eutech Instruments; Thermo Scientific). Organic carbon (%) was determined by dichromate oxidation (Walkley and Black, 1934), available N (kg ha^{-1}) by alkaline potassium permanganate distillation method (Subbiah and Asija, 1956), available P (kg ha^{-1}) by extracting samples with 0.5 M $NaHCO_3$ and determining P colorimetrically using molybdate (Olsen *et al*., 1954), and available K (kg ha^{-1}) by 1N NH_4OAc (pH 7) as an extractant (Jackson, 1973).

3. RESULTS AND DISCUSSION

Pruned material and plant growth characters of ber

The plants were pruned during May, 2015 and 2016 for new growth, and growth observations were taken in December for both the years. During 2015, pruned material ranged from 3.72 to 8.35 kg $plant^{-1}$ being maximum in T7 on fresh weight basis; however on dry weight basis, it ranged from 2.20 to 4.80 kg $plant^{-1}$ being maximum in T7 (Table 1). Maximum collar diameter was recorded in T1 and minimum in T4, however difference among various treatments was found non-significant. Canopy spread was recorded maximum in T1 (East-West direction) and T6 (North-South direction), however treatments did not show any significant variation. During 2016, the pruned material ranged from 5.55 to 9.58 kg $plant^{-1}$ on fresh weight basis and 3.04 to 5.22 kg $plant^{-1}$ on dry weight basis. In both the cases, treatments varied significantly and recorded highest values in T8 for fresh and dry weight. The collar diameter was recorded maximum in T1 which was at par with T3, T8, T6 and T5. The variation in canopy spreads (East-West and North-South direction) was found non-significant. More yield of pruned material and improvement in growth characters might be due to

Table 1. Effect of treatments on pruned material and plant growth characters of ber (cv. Seo) fruits.

Treatment	2014-15					2015-16				
	Pruned material (kg $plant^{-1}$)		Collar diameter	Canopy spread (cm)		Pruned material (kg $plant^{-1}$)		Collar diameter	Canopy spread (cm)	
	Fresh	Dry	(cm)	East-West	North-South	Fresh	Dry	(cm)	East-West	North-South
T1*	7.13	3.94	10.29	451.33	444.28	8.23	4.60	10.95	4.65	4.75
T2	6.42	3.47	9.19	421.19	414.11	5.55	3.04	9.36	4.57	4.47
T3	5.89	3.40	9.34	423.01	420.34	6.90	3.88	10.24	4.45	4.47
T4	3.72	2.20	7.76	347.50	334.17	8.44	4.53	8.14	4.09	3.89
T5	5.72	3.37	9.37	430.06	425.50	6.72	3.84	9.65	4.71	4.72
T6	6.61	3.65	10.13	439.42	454.75	5.82	3.15	9.91	4.57	4.42
T7	8.35	4.80	8.83	406.67	418.67	7.96	4.43	9.30	4.64	4.54
T8	8.03	4.30	8.96	450.61	448.39	9.58	5.22	9.93	4.79	4.75
T9	7.22	3.67	8.89	383.78	394.00	5.60	3.32	9.47	4.34	4.37
$LSD_{0.05}$	2.48	NS	NS	NS	NS	2.183	1.251	1.42	NS	NS

*T1- ber (100% recommended dose of fertilizer (RDF)), T2- ber (100% RDF) + sesame-lentil, T3- ber (75% RDF), T4- ber (75% RDF) + sesame-lentil, T5- ber (75% RDF) + AM fungi, T6- ber (75% RDF) + AM fungi + sesame-lentil, T7- ber (75% RDF) + *T. harzianum,* T8- ber (75% RDF) + *T. harzianum* + sesame-lentil, T9- ber (75% RDF) + AM fungi + *T. harzianum* + sesame-lentil and T10- sesame-lentil

supplementation of nutrients with application of *Trichoderma* causing proliferation and growth of fungal microbes. The increased population of *Trichoderma* might play positive role to make available plant nutrients in rhizosphere that increased growth and development and ultimately enhanced biomass. Our results are in support of Haque *et al.* (2012) who reported similar results while working on mustard and tomato.

Fruit characters and yield

During 2014-15, variations in all recorded fruit characters (except number of fruits and fruit yield plant^{-1}) were found non-significant (Table 2). However, based on absolute values, maximum fruit weight, pulp weight, pulp/stone ratio and total soluble solids (TSS) were recorded in T3, T3, T2 and T9, respectively. Maximum number of fruits plant^{-1} was recorded in T1 which was statistically at par with T8, and maximum fruit yield was recorded in T8 which was found at par with T3 and T1.

During 2015-16, treatments significantly affected all fruit characters, except pulp/stone ratio (Table 2). Maximum fruit weight was found in T8 which was at par with T3, T6, T1 and T4. Maximum pulp weight was recorded in T8 which was at par with T3, T6 and T1. Maximum TSS recorded in T7 which was at par with all remaining treatments (except T3 and T8). Maximum number of fruits plant^{-1} was recorded in T1 and it was at par with T8, T6, T3 and T5. Fruit yield was recorded maximum in T8 and it was recorded at par with T1, T3 and T6. Yield improvement in T8 might be due to increase in fruit weight/number of fruits which might have increased due to application of *Trichoderma*. The study revealed that the use of *Trichoderma* with 75% RDF can reduce the input of 25% chemical fertilizer in ber. Similar result was reported by Thakur *et al.* (2016) in plum (cv. Santa Rosa). Haque *et al.* (2012) advocated that application of *Trichoderma*-enriched biofertilizer along with N fertilizer could save at least 50% N fertilizer for tomato and mustard. According to Contreras-Cornejo *et al.* (2009), *Trichoderma* synthesizes auxin which stimulates development of lateral root and thereby plant attained better growth, yield and quality of produce. Increased yield by *Trichoderma* could also be due to stimulation of nutrient transfer from soil to roots, as *Trichoderma* colonizes the interior of roots, regulates IAA and ethylene production or through production of growth prompting compounds such as kinetin (Kadian *et al*., 2013). Beneficial effect of *Trichoderma* application has been reported by various researchers in different plant/crops (Elad *et al*., 2006; Singh *et al.,* 2010).

Intercrops yield

During 2014-15, the lentil seed yield ranged between 815-1069 kg ha^{-1} and straw yield between 1051-1379 kg ha^{-1} under different treatments. Maximum seed and straw yield was recorded in T10 which was at par with T6. These were significantly higher than remaining treatments. Whereas in sesame, seed yield ranged between 562-704 kg ha^{-1} under various treatments. Maximum seed and straw yield were recorded in T10 and T6 which was significantly higher than other treatments. During 2015-16, both the treatments (T10 and T6) showed almost similar trend (Table 3). Thus,

Table 2. Effect of treatments on fruit characters and yield of ber (cv. Seo) fruits.

Treatment	2014-15						2015-16					
	Fruit Weight (g)	Pulp weight (g)	Pulp/ stone ratio	TSS (^{0}B)	Number of fruits plant^{-1}	Yield (kg plant^{-1})	Fruit weight (g)	Pulp weight (g)	Pulp/ stone ratio	TSS (^{0}B)	Number of fruits plant^{-1}	Yield (kg plant^{-1})
T1*	15.19	14.25	15.18	17.25	1481.2	22.56	16.77	15.48	11.95	17.99	2971.2	50.41
T2	14.34	13.48	15.68	16.71	1181.4	16.88	15.31	14.15	12.11	17.86	2211.5	33.80
T3	17.09	15.89	14.03	16.14	1326.1	22.66	19.03	17.69	13.21	16.79	2607.9	49.62
T4	12.27	11.59	15.06	16.98	1026.7	12.60	15.88	14.68	12.21	17.98	1759.9	28.11
T5	13.45	12.57	14.17	16.30	1280.1	17.39	14.42	13.19	10.68	19.48	2566.3	37.13
T6	14.16	13.28	15.23	16.83	1240.0	17.54	17.61	16.40	13.58	16.18	2705.9	47.45
T7	14.77	13.86	15.41	14.89	1149.5	17.17	12.37	11.22	9.71	20.88	2245.8	27.58
T8	15.59	14.60	14.86	16.06	1477.5	23.02	19.96	18.73	15.46	15.24	2896.1	57.52
T9	12.44	11.65	14.80	17.63	1412.4	17.44	14.07	12.99	12.10	17.63	2040.8	28.87
$LSD_{0.05}$	NS	NS	NS	NS	182.5	4.96	4.07	4.02	NS	3.13	494.8	14.29

*T1- ber (100% recommended dose of fertilizer (RDF)), T2- ber (100% RDF) + sesame-lentil, T3- ber (75% RDF), T4- ber (75% RDF) + sesame-lentil, T5- ber (75% RDF) + AM fungi, T6- ber (75% RDF) + AM fungi + sesame-lentil, T7- ber (75% RDF) + *T. harzianum,* T8- ber (75% RDF) + *T. harzianum* + sesame-lentil, T9- ber (75% RDF) + AM fungi + *T. harzianum* + sesame-lentil and T10- sesame-lentil

the study revealed that the treatment involving AM fungi produced more seed and straw yield in both the crops during both the study years. Increase in yield with the application of AM fungi might be due to an increase in nutrients uptake and plant growth (Kumar *et al.*, 2017) and less susceptibility to diseases (Shukla *et al.*, 2014). Jha *et al.* (2014) advocated that AM fungi can increase uptake of nutrients especially which are relatively immobile in the soil such as P and consequently increase growth and biomass of crops which ultimately influence the crop yield. Our results are in conformity with Amirnia *et al.* (2019) who reported beneficial effect of mycorrhizal fungi along with *Azotobacter* on photosynthesis, plant growth and seed yield in lentil under water shortage conditions. Rahman *et al*. (2017) reported increase in germination percentage, growth and yield of mycorrhizae inoculated lentil plants over non-mycorrhizal plants. Yaseen *et al*. (2016) reported up to 45% increase in seed yield in treatments consisting of AM fungi. Prakash and Tandon (2002) reported enhanced biomass, nutrient uptake and yield of sesame in treatments having AM fungi along with conventional P fertilizer. Gholinezhad and Darvishzadeh (2019) also reported higher yield of sesame due to inoculation of AM fungi which might be due to the improvement of seed yield components such as the number of capsule plant^{-1}, the number of seeds capsule^{-1} and the 1000 seed weight.

Land equivalent ratio (LER)

The data presented in Table 4 revealed that the intercrops and bio-inoculants (*Trichoderma* and AM fungi) influenced the yield of ber. During both studied years, maximum yield of ber (4.79 and 11.96 t ha^{-1}) was recorded with the intercrop during the same period. In each treatment, LER was found greater than one during experimental period. Maximum LER was recorded in treatment T8 in 2014-15 and T6 in 2015-16, which was almost equal to T8. It means 82% and 92% more land would be needed to produce the combined yields of all three crops if they were to be grown as pure stands. Similar results were also reported in banana intercropping (Mahant *et al*., 2012), multi-storied cropping system (Nimbolkar *et al*., 2016) and in mango intercropping (Rout and Bisen, 2016). The increase in LER could also be be due to application of AM fungi (T6) and *Trichoderma* (T8), as AM fungi enhanced the yield of intercrops whereas *Trichoderma* influence the yield of main crop i.e. ber.

Soil properties

The applied treatments have caused significant variation in all the studied soil parameters, except soil pH in surface soil (0-15 cm); however, in sub-surface soil (15-30 cm), significant variations were noticed in EC, organic carbon and available P and K (Table 5). In general, all the treatments had shown better soil test values than the initial soil properties. In comparison to control, all the treatment showed more values of SOC, available N, P and K in both surface and sub-surface soil. In general, soil test values were more in surface soil than in sub-surface soil. In surface soil, maximum pH and available N were observed in T1; EC and organic carbon in T7; and available P and K in T8, while respective minimum values were observed in T10. Similar trend was observed in sub-surface soil

Table 3. Effect of treatments on lentil and sesame yield in ber based agri-horti system.

Treatment	2014-15				2015-16			
	Lentil yield (kg ha^{-1})		Sesame yield (kg ha^{-1})		Lentil yield (kg ha^{-1})		Sesame yield (kg ha^{-1})	
	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
T2*	854	1127	573	733	743	1115	462	596
T4	874	1152	562	711	763	1145	454	586
T6	1017	1312	695	886	927	1402	584	753
T8	815	1059	601	737	709	1073	457	590
T9	821	1051	593	776	725	1079	483	623
T10	1069	1379	704	913	975	1455	592	764
CV(%)	17	18	10	10	18.91	19.82	16.94	19.82
$LSD_{0.05}$	141	223	92	101	135	202	87	117

*T2- ber (100% RDF) + sesame-lentil, T4- ber (75% RDF) + sesame-lentil, T6- ber (75% RDF) + AM fungi + sesame-lentil, T8- ber (75% RDF) + *T. harzianum* + sesame-lentil, T9- ber (75% RDF) + AM fungi + *T. harzianum* + sesame-lentil and T10- sesame-lentil also, barring few exceptions. Relatively high content of available P and K in T6 and T8 can be attributed to the presence of AM fungi and *Trichoderma* which might have solubilized native as well fertilizer P in soil. Low content of available P and K in T9 applied with both AM fungi and *Trichoderma* may be attributed to

Table 4. Land equivalent ratio (LER) of ber based intercropping system.

Treatment	2014-15					2015-16					Procedure used for LER calculation
	Ber	Intercrops grain yield (t ha^{-1})			LER	Ber	Intercrops grain yield (t ha^{-1})			LER	
	Fruit Yield (t ha^{-1})	Sesame	Lentil	Cumulative		fruit yield (t ha^{-1})	Sesame	Lentil	Cumulative		
1	2	3	4	5 (3+4)	-	2	3	4	5 (3+4)		
T1*	4.69	-	-	-	-	10.86	-	-	-	-	-
T2	3.51	0.57	0.85	1.42	1.55	7.03	0.46	0.74	1.20	1.41	$2T_2/2T_1 + 5T_2/5T_{10}$
T3	4.71	-	-	-	-	10.32	-	-	-	-	-
T4	2.62	0.56	0.87	1.43	1.37	5.85	0.45	0.76	1.21	1.34	$2T_4/2T_3 + 5T_4/5T_{10}$
T5	3.62	-	-	-	-	7.72	-	-	-	-	-
T6	3.65	0.70	1.02	1.72	1.74	9.87	0.58	0.93	1.51	1.92	$2T_6/2T_3 + 5T_6/5T_{10}$
T7	3.57	-	-	-	-	5.74	-	-	-	-	-
T8	4.79	0.60	0.82	1.42	1.82	11.96	0.46	0.71	1.17	1.91	$2T_8/2T_3 + 5T_8/5T_{10}$
T9	3.63	0.59	0.82	1.41	1.57	6.00	0.48	0.73	1.21	1.35	$2T_9/2T_3 + 5T_9/5T_{10}$
T10	-	0.70	1.07	1.77	-	-	0.59	0.98	1.57	-	-

*T1- ber (100% recommended dose of fertilizer (RDF)), T2- ber (100% RDF) + sesame-lentil, T3- ber (75% RDF), T4- ber (75% RDF) + sesame-lentil, T5- ber (75% RDF) + AM fungi, T6- ber (75% RDF) + AM fungi + sesame-lentil, T7- ber (75% RDF) + *T. harzianum,* T8- ber

Table 5. Effect of treatments on soil properties (rhizosphere soil taken 0.5 m away from tree trunk in tree-basin) at the end of the experiment.

Treatment	Surface soil (0-15 cm)						Sub-surface soil (15-30cm)					
	PH (1:2)	EC (uS m^{-1})	Organic carbon (%)	Available nutrient (kg ha^{-1})			pH (1:2)	EC (uS m^{-1})	Organic carbon (%)	Available nutrient (kg ha^{-1})		
				N	P	K				N	P	K
T1*	7.10	379.3	0.86	296.9	24.6	202.9	6.80	183.7	0.7	259.2	19.6	140.6
T2	6.60	245.0	0.76	263.4	23.1	218.0	6.38	136.3	0.4	255.1	16.6	141.4
T3	6.76	275.7	0.83	250.9	26.5	220.5	6.67	172.0	0.5	246.7	19.5	164.2
T4	6.63	324.7	0.80	253.4	25.5	214.6	6.31	176.3	0.7	259.2	21.1	159.9
T5	6.45	242.7	0.77	280.2	26.9	217.2	6.34	190.7	0.5	263.4	20.5	171.7
T6	6.98	285.7	0.78	280.2	30.0	234.8	6.82	171.3	0.5	246.7	18.6	199.5
T7	6.39	390.3	0.91	290.2	28.6	221.4	6.03	209.3	0.6	250.9	22.3	197.8
T8	6.35	279.7	0.73	258.5	30.3	272.7	6.44	154.0	0.5	252.9	20.2	181.8
T9	6.48	250.0	0.66	273.5	21.2	208.7	5.74	125.7	0.4	242.5	12.3	172.6
T10	5.98	164.3	0.49	246.7	17.7	119.6	6.05	136.3	0.3	230.1	9.0	108.6
$LSD_{0.05}$	NS	105.96	0.10	19.31	4.140	37.71	NS	48.50	0.12	NS	2.08	26.27

*T1- ber (100% recommended dose of fertilizer (RDF)), T2- ber (100% RDF) + sesame-lentil, T3- ber (75% RDF), T4- ber (75% RDF) + sesame-lentil, T5- ber (75% RDF) + AM fungi, T6- ber (75% RDF) + AM fungi + sesame-lentil, T7- ber (75% RDF) + *T. harzianum,* T8- ber (75% RDF) + *T. harzianum* + sesame-lentil, T9- ber (75% RDF) + AM fungi + *T. harzianum* + sesame-lentil and T10- sesame-lentil

antagonistic interaction effects of both the microbes (Kaewchai *et al*., 2009).

4. CONCLUSION

The study concluded that use of *Trichoderma* enhanced production of ber cv. Seo, whereas AM fungi produced at par yield with pure crop (control) of sesame and lentil in semi-arid conditions of Bundelkhand region. This suggests that use of *Trichoderma* has beneficial effect on ber whereas AM fungi are good for intercrops. There is no doubt that *Trichoderma* is having potential to achieve attractive yield and in saving chemical fertilizers and can be recommended to the orchardists.

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