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Effects of Some Indigenous Ectomycorhyza and Nitrogen Fertilizer on the Growth and Yield of Sorghum (*Sorghum bicolor* L. moench) in Bauchi State Nigeria

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ABSTRACT

The experiment was conducted to study the effects of nitrogen fertilizer and ectomycorhiza on the growth and yield of sorghum at the teaching and research farm of the Faculty of agriculture and agricultural technology, Abubakar Tafawa Balewa University, Bauchi (10°22' N and 9°47'E). The treatments consisted of two species of mycorhiza (Glomus and Gigaspora spp.) and three levels of nitrogen fertilizer (0, 30 and 60 kg/ha). These were factorially combined to give six treatments combination and laid out in a randomized complete block design (RCBD) with four replications. Data was collected on plant height, number of leaves, leaf area, stem girth, number of prop root and panicle length. Others are number of spikes per panicle, 1000 grain weight and grain yield. All data collected were subjected to analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) was adopted during the analysis to separate significantly different treatments means. The result of the experiment revealed a significant (P=0.05) difference among the various treatments used throughout the study period. The result further indicated that, application of 30 and 60 kg N/ha produced statistically (P=0.05) similar result but significantly (P=0.05) better than the control in promoting growth and yield of sorghum. The result also showed that, among the two species of mycorhiza used, Glomus spp. was found to be statistically (P=0.05) better than Gigaspora spp. in promoting growth and yield of sorghum. Study on the interaction revealed that, application of 60 kg N/ha to sorghum inoculated with Glomus spp. gave significantly (P=0.05) higher growth and yield of sorghum than the other treatments combination and all the treatments were better than the control. Based on the result of this findings, application of 30 kg N/ha to sorghum inoculated with Glomus spp. can be adopted by farmers in the study area for sorghum production.
Keywords: *sorghum, nitrogen, mycorhiza, inoculation, growth and yield*

INTRODUCTION

Agriculture is the dominant occupation in developing countries, which involves major socioeconomic and cultural activities. The vast majority of people particularly in sub-Saharan Africa depend on rain-fed agriculture for their livelihoods (Bekele *et al.* 2014). Paradoxically, food insecurity and malnutrition is a norm in this region, with millions of poor people often being afflicted (Schmidhuber and Tubiello, 2007; Otaha, 2013; Bekele *et al.* 2014). Unfortunately, many environmental issues pose a lot of constraints to agricultural production which perpetuate food crisis among the populace. Such environmental issues are mainly climatic change-induced drought and soil nutrient deficiency as a result of soil nutrient mining by continuous cultivation with low supply of fertilizer (Hrynkiewicz and Baum, 2011; Sasson, 2012; Zakari, *et al.* 2014). Furthermore, this is projected to worsen with the current and forecasted climate change. Drought often increases desertification in arid lands and finally reduction in crop productivity (Schmidhuber and Tubiello, 2007). It was reported that, soil productivity is decreasing globally due to increasing soil degradation with nearly 65% of the agricultural land in Africa as result of erosion, nutrient depletion and lower levels of soil organic matter among others. Soil degradation leads to increased pressure and bring more land into crop production at the expense of forests and marginal lands, which are habitats for rare plant and animal species which are facing the danger of extinction (Hrynkiewicz and Baum, 2011). There is therefore an urgent need to reduce the vulnerability of developing countries by essentially optimizing crop yield. However, projection of increase in food production must be accomplished on the existing cultivated areas because the expansion of new land is limited due to environmental concerns (Jha and Kumar 2011; Bekele *et al.* 2014). To solve the dilemma of increasing agricultural production without compromising environmental sustainability and meet the food demand of a soaring population by avoiding catastrophic losses in production, maintenance of soil fertility on the current arable land and investments in crops adaptation to drought are critically essential (Sharma *et al.* 2010; Hrynkiewicz and Baum, 2011). A cheaper and efficient strategy to increase soil health and productivity in agricultural lands is the applications of suitable microorganisms (biofertilization), particularly mycorrhizal fungi that promote plant growth (Hrynkiewicz and Baum, 2011). The mycorrhizas are mutualistic associations between higher roots and specific soil macro-fungi that significantly improve the absorption of water and nutrients by the plant and also provide protection from root pathogens (Rossi *et al.* 2007). They colonize the plants' roots biotrophically and develop an extramatrical mycelium that helps the plants to acquire mineral nutrients and soil water more efficiently. The fungus in the other hand gets photosynthates from the plant. These greatly influence the survival, growth and establishment of crops, especially during drought and in nutrient deficient soils (Khurana and Singh, 2001; Sanon *et al.* 2010) thereby increases crop productivity in degraded agricultural systems (Auc-Ina *et al.* 2007; Hrynkiewicz and Baum, 2011; Millar and Ballhorn, 2013).

However, the effectiveness of this relationship depends on local environmental factors and time (Klavina, 2015; Torres-Aquino *et al.* 2017). Some plant species may perceive a particular mycorrhizal fungus as antagonists. The effect of mycorrhizal fungi on plant growth also depends on other environmental factors. When soil water and fertility are not limited, usually there is no benefit, and plant growth can even be slightly reduced in the presence of mycorrhizal fungi due to demand of photosynthetic assimilates. It is also reported that a mycorrhizal fungus may be mutualistic with one host plant species but parasitic on another (Auc-Ina *et al.* 2007; Rossi *et al.* 2007). The most suitable mycorrhizal inoculants to be used are controlled ectomycorrhization. This is the use of pure culture of fungal mycelia or spores of specific compatible mycorrhiza. However, controlled mycorrhization method is relatively complex and is associated with so many challenges, especially that of ectomycorrhizal fungi. These include slowness of growth, contamination by plant pathogens and any free-living microorganisms, accumulation of toxic metabolites, loss of viability and infectivity, insufficient knowledge of biochemistry and physiology of many ectomycorrhizal fungi, difficulty in application and financial implication of production cost. These restrict large-scale production which is usually essential for practical applications by the general populace (Rossi *et al.*, 2007; Sanon *et al*, 2010). Moreover, laboratory production of pure culture and experimental results may be far from reality because of interaction with other soil organisms and physical environmental cues (Klavina, 2015). For these reasons, the use of mycorrhizas in agriculture and forestry is rarely applied especially in the developing countries. Fortunately, mycorrhizal soil inoculants (a method by which thin layer of soil obtained from under trees and mixed with the planting soil or growth substrate) is easy and by far cheaper

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way of obtaining the desired mycorrhizal benefits. It also has the advantage of inoculating the seedlings with fungal strains that are adapted to the specific environment. This experiment was conducted to study the effects of nitrogen fertilizer and ectomycorrhizal soil inoculum on the growth and yield of sorghum.

MATERIALS AND METHODS

The experiment was conducted at the teaching and research farm of the Faculty of agriculture and agricultural technology, Abubakar Tafawa Balewa University, Bauchi (10°22' N and 9°47'E), located in the Northern Guinea savannah agro ecological zone of Nigeria. The materials for the experiment consisted of two species of mycorrhiza (*Glomus* and *Gigaspora spp.*), urea fertilizer and sorghum (variety; CRS-01). The treatments consisted of two species of mycorrhiza (*Glomus* and *Gigaspora spp.*) and three levels of nitrogen fertilizer (0, 30 and 60 kg/ha), factorially combined to give a total of six treatments combination and laid out in a randomized complete block design (RCBD) with four replications. Net plot size of 4m^2 was adopted for the experiment and a border row of 50cm was left between plots while 200cm was left out as a walk way between replications. The experimental soil was collected from intensively cultivated land with poor nutrient status and sterilized for one hour. One kilogram of the soil was placed in a polythene bag and bury in the plots at a spacing of 25 x 75 cm. On top of the soil inside the bag, four table spoonful of the inoculum containing mycorhizal spores was placed. For the control plots, a sterile soil was used to avoid any mycorrhizal propagules that may be present. Six seeds of sorghum were planted on the treated soils inside the bags and covered with the same soil and thinned to two stands per hill one week after emergence. Data was collected at biweekly interval on plant height, number of leaves, leaf area, stem girth, number of prop root and panicle length. Others are number of spikes per panicle, 1000 grain weight and grain yield. All data collected were subjected to analysis of variance and Duncan's multiple range test (DMTR) was adopted in separating the means.

RESULTS AND DISCUSSION

1. Effects of Some Indigenous Ectomycorrhiza and Nitrogen Fertilizer on Plant Height of SorghumThe result as presented in table 1 revealed that, there is a significance (P=0.05) difference among the various levels of nitrogen fertilizer used throughout the study period. The result further revealed that, application of 60 kg N/ha gave statistically (P=0.05) similar result with 30 kg/ha but all the treatments were significantly (P=0.05) better than the control throughout the study period. The significant difference observed in this study indicated the importance of nitrogen fertilizer to the growth of sorghum. This is in line with the result of Zakari *et al.* (2014) who reported that, nitrogenous fertilizer play a key role in the growth and yield of sorghum. On the two species of mycorrhiza used, the results indicated that, *Glomus spp.* produced significantly (P=0.05) taller plants than *Gigaspora spp.* throughout the study period. This indicated the influence of mycorrhizal inoculation on the performance of sorghum. The result of the present findings lend support to the findings of Hrynkiewicz and Baum (2011) who reaffirmed that, a cheaper and efficient strategy to increase soil health and productivity in agricultural lands is the applications of

suitable microorganisms (biofertilization), particularly ectomycorrhiza fungi that promote plant growth.

2. Effects of Some Indigenous Ectomycorhiza and Nitrogen Fertilizer on Number of Leaves of Sorghum Table 2 presented the result on effects of nitrogen fertilizer and ectomycorrhiza on number of leaves of sorghum. The result revealed a significant (P=0.05) difference among the treatments used throughout the study period. The result further indicated that, 60 and 30 kg N/ha produced statistically (P=0.05) similar number of leaves but significantly (P=0.05) better than the control throughout the study period. The statistically higher number of leaves observed in this study with the application of nitrogen fertilizer could be as a result of the effect of nitrogen as a major constituent of plant metabolism and protein synthesis. This is in conformity with the report of Fagam *et al.* (2009) who reported that increasing nitrogen fertilizer increases plant growth. Mycorrhiza on the other hand, *Glomus spp.* proved to be significantly (P=0.05) better than *Gigaspora spp.* in promoting higher number of leaves throughout the study period. The increase in number of leaves as observed in this study revealed the importance of mycorrhizal inoculation in sorghum production. The result of this findings lend its support from the findings of Otaha (2013) who reported that, mycorrhiza play a crucial role in biogeochemical cycling in ecosystems and form a water-stable aggregates necessary for good soil quality by their external mycelium in association with other soil organisms.

3. Effects of Some Indigenous Ectomycorrhiza and Nitrogen Fertilizer on Leaf Area of Sorghum The result as presented in table 3 revealed that, there exist a significant (P=0.05) difference among various treatments used. The result also indicated that, except at 6 WAS where application of 60 kg N/ha produced significantly (P=0.05) wider leaf than 30 kg, 60 and 30 kg N/ha gave statistically (P=0.05) same leaf area of sorghum but significantly (P=0.05) wider than the control treatment throughout the study period. The significant difference observed in this study could be as a result of increased in leaf area due mainly to the addition of nitrogen fertilizer. This is in agreement with the findings of Sanginga *et al.* (2002) and Bado *et al.* (2006) who reported that nitrogen has a significant contribution to vegetative growth of plants. Study on mycorrhizal inoculation revealed that, except at 4 WAS where no significant (P=0.05) difference was observed, *Glomus spp.* consistently produced significantly (P=0.05) higher leaf area than *Gigaspora spp.* throughout the study period. Result of the interaction of nitrogen and mycorrhiza (Table 4) revealed that, application of 60 kg N/ha to sorghum inoculated with *Glomus spp.* was found to be significantly (P=0.05) better than all the other treatments combination in terms of leaf area of sorghum. The wider leaves observed under *Glomus spp.* indicated its superiority in promoting growth of sorghum to *Gigaspora spp.* It could also be due to the effects of mycorrhiza in helping the plant to acquire more nutrient in the soil. This corroborates the report of Jha and Kumar (2011) that ectomycorrhizal fungus can colonize the plant's roots biotrophically and develop an extramatrical mycelium that helps the plants to acquire mineral nutrients and soil water more efficiently.

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4. Effects of Some Indigenous Ectomycorrhiza and Nitrogen Fertilizer on Stem Girth of Sorghum Table 5 presented result of the effects of nitrogen fertilizer and ectomycorrhiza on stem girth of sorghum. The result showed that, there is a significant (P=0.05) difference among the treatments used on stem girth throughout the study period. The result further indicated that, 30 and 60 kg N/ha gave statistically (P=0.05) similar stem girth but significantly (P=0.05) thicker than the control throughout the study period. This indicated the importance of fertilizer application in promoting stem girth of sorghum. This is in conformity with the result of Bado *et al.* (2011) who reported that, nitrogen availability after growing legume from previous season and efficiency of fertilizer nitrogen on the subsequent crop is under the influence of weather condition, especially rainfall and temperature. Mycorrhizal inoculation on the other hand indicated that, no significant (P=0.05) difference was observed between the two strains under study. This indicated that, mycorrhizal inoculation has no effect on the stem girth of sorghum. The result of the present findings is not in agreement with an earlier report by Hrynkiewicz and Baum (2011) who reported that, ectomycorrhiza play a crucial role in biogeochemical cycling of ecosystems leading to increase in plant growth.

5. Effects of Some Indigenous Ectomycorrhiza and Nitrogen Fertilizer on Number of Prop Root of Sorghum The result as presented in table 5 revealed that, there exist a significant (P=0.05) difference among the treatments used throughout the study period. The result further showed that, application of 60 and 30 kg N/ha produced statistically (P=0.05) same number of prop root but significantly (P=0.05) better than the control. This proved the importance of nitrogen as a basic constituent of plant metabolism. The result of this study lend support to the findings of Oseni (2010) who reported a similar trend in cowpea – sorghum intercrop. On the two species of mycorrhiza used, the result revealed that, *Glomus spp.* gave significantly (P=0.05) higher number of prop root than *Gigaspora spp*. The increase in number of prop root observed in this study could be due to the increase in soil quality as a result of external mycelium formed by mycorrhizal fungi which lead to the formation of good aggregate stability. This is in agreement with the findings of Zakari *et al.,* (2014) who reaffirmed that, ectomycorrhiza form water-stable aggregates necessary for a good soil quality by their external mycelium in association with other soil organisms.

6. Effects of Some Indigenous Ectomycorrhiza and Nitrogen Fertilizer on Panicle Length of Sorghum Table 5 also presented the result on the effect of nitrogen fertilizer and ectomycorrhiza on panicle length of sorghum. The result revealed a significant (P=0.05) different among the treatments used. The result further indicated that, application of 30 and 60 kg N/ha produced statistically (P=0.05) similar panicle length but significantly (P=0.05) better than the control. The significant increase in panicle length as a result of nitrogen fertilizer application indicated the influence of fertilizer application on the yield components of sorghum. The result of the present study is in line with the report of Fagam *et al.* (2009) who indicated nitrogen as a basic component of plant physiological activities while working on nitrogen fertilization in cereal production. Study on the two strains of mycorrhiza however revealed that, *Glomus spp.* produced significantly (P=0.05) bigger heads of sorghum than *Gigaspora spp*. The significant increase in panicle length as

observed in this study revealed the effect of ectomycorrhiza in improving the soil condition for better nutrient uptake by crop. This corroborates the findings of Bellgard and Williams (2011) who affirmed that, mycorrhizas are mutualistic associations between higher roots and specific soil macro-fungi that significantly improve the absorption of water and nutrients by the plant and also provide protection against root pathogens.

7. Effects of Some Indigenous Ectomycorrhiza and Nitrogen Fertilizer on Number of Spikes per Panicle of Sorghum The result as presented in table 6 revealed a significant (P=0.05) difference among the treatments used. The result further showed that, 60 and 30 kg N/ha produced statistically (P=0.05) similar number of spikes but significantly (P=0.05) better than the control. The significant difference observed in this experiment on number of spikes per head where the rate of 60 and 30 kg N/ha proved to be better than the control revealed that, the increase in number of spike with application of nitrogen fertilizer indicated the significance of inorganic fertilizer on amounts of spike in sorghum. This could also be due to the effect of nitrogen fertilizer in increasing yield of crops. The results of the present study lend support to the results of Musa *et al.* (2011) who reported a similar trend in legume – cereal intercrop. The two mycorrhizal species on the other hand, higher number of spikes were significantly (P=0.05) produced by *Glomus spp*. than *Gigaspora spp*. The statistical analysis carried out in this experiment where *Glomus spp*. proved to be better than *Gigaspora spp*. indicated the better adaptation of the specie in the savanna. The increase in number of spikes due to *Glomus spp*. could be as a result of increase in soil fertility by the specie. The present assumptions support the report of Sanginga *et al.* (2002) who reported a significant increase in number of spikes of sorghum grown on soil inhabited by mycorhiza.

8. Effects of Some Indigenous Ectomycorrhiza and Nitrogen Fertilizer on 1000 Grain Weight of Sorghum. Table 6 also presented result on the effects of nitrogen fertilizer and ectomycorrhiza on 1000 grain weight of sorghum. The result revealed a significant (P=0.05) difference among the treatments used. The result further showed that, 30 and 60 kg N/ha gave statistically (P=0.05) same 1000 grain weight but significantly (P=0.05) heavier than the control. Result of the interaction (Table 7) on the other hand revealed that, application of 60 kg N/ha to sorghum inoculated with *Glomus spp*. produced significantly (P=0.05) heavier grains than the other treatments combination, however all the treatments were better than the control. The significant difference observed in this study indicated the effect of nitrogen as a basic component of many physiological processes in plants. The present findings is in support of the report of Marschner (2005) who reported that, nitrogen is a basic constituent of many compounds of physiological importance to plant metabolism such as chlorophyll, nucleotides, alkaloids, proteins, enzymes, hormones and vitamins. Study on the mycorrhizal inoculation revealed that, *Glomus spp*. produced significantly (P=0.05) heavier grains than *Gigaspora spp*. This indicated the importance of mycorrhiza in forming mutualistic association with sorghum. The result of this findings lend support to the report of Bado *et al.* (2011) who reported an increase in the yield of sorghum following legumes in rotation. This also corroborates the findings of Bellgard and Williams (2011) who affirmed that, mycorrhizas are mutualistic associations between higher roots and specific soil macro-

fungi that significantly improve the absorption of water and nutrients by the plant and also provide protection against root pathogens.

9. Effects of Some Indigenous Ectomycorrhiza and Nitrogen Fertilizer on Grain Yield of Sorghum. Effects of nitrogen fertilizer and ectomycorrhiza on grain yield of sorghum is presented in table 6. The result as presented revealed that, a significant (P=0.05) difference exist among the treatments used. The result further indicated that, 30 and 60 kg N/ha produced statistically (P=0.05) similar grain yield but significantly (P=0.05) better than the control. The result of the interaction (Table 7) of nitrogen and ectomycorrhiza revealed that, application of 60 kg N/ha to sorghum inoculated with *Glomus spp*. gave significantly (P=0.05) higher yield of sorghum than the other treatments combination. However, all the treatments were better than the control in promoting grain yield of sorghum. The increase in yield with nitrogen fertilizer application as observed in this study clearly indicates the importance of inorganic fertilizer in the performance of sorghum. This indicated the effect of nitrogen as a basic component of many physiological processes in plants. The present findings is in support of the report of Marschner (2005) who reported that, nitrogen is a basic constituent of many compounds of physiological importance to plant metabolism such as chlorophyll, nucleotides, alkaloids, proteins, enzymes, hormones and vitamins. The two species of mycorrhiza on the other hand, *Glomus spp*. was proved to be significantly (P=0.05) better than *Gigaspora spp*. in promoting grain yield of sorghum. The increase in grain yield with mycorrhizal inoculation as observed in this study revealed the effect of ectomycorrhiza in improving the soil condition for better nutrient uptake by crop. This corroborates the findings of Bellgard and Williams (2011) who affirmed that, mycorrhizas are mutualistic associations between higher roots and specific soil macro-fungi that significantly improve the absorption of water and nutrients by the plant and also provide protection against root pathogens. It could also be due to the effects of mycorrhiza in helping the plant to acquire more nutrient in the soil. This corroborates the report of Jha and Kumar (2011) that ectomycorrhizal fungus can colonize the plant's roots biotrophically and develop an extramatrical mycelium that helps the plants to acquire mineral nutrients and soil water more efficiently.

CONCLUSION AND RECOMMENDATION

The results of this study revealed that crop's response to mycorrhizal soil inoculums differs with different species of mycorrhiza. The effect of mycorrhizal soil inoculums on the growth and yield of sorghum cannot be overemphasized. Growth and yield of sorghum was observed to increase with mycorrhizal inoculation irrespective of the level of nitrogen application. Based on the result of this findings, application of 30 kg N/ha to sorghum inoculated with *Glomus spp*. of mycorrhiza can be recommended for sorghum production in the study area.

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Table 1: Effects of nitrogen fertilizer and ectomycorhiza on plant height of sorghum

Treatments	WAS 4	6	8	10
Nitrogen (kg/ha)				
0	32.32[b]	67.34[b]	131.65[b]	133.25[b]
30	49.23[a]	107.18[a]	179.21[a]	181.94[a]
60	46.02[a]	103.20[a]	186.40[a]	188.89[a]
LS	**	**	**	**
SE±	2.13	2.89	7.01	6.95
Mycorhyza				
Glomus spp	43.69[a]	93.98[a]	169.18[a]	171.52[a]
Gigaspora spp	40.36[b]	91.16[b]	162.32[b]	164.53[b]
LS	*	**	**	*
SE±	1.07	0.86	2.13	2.21
Interaction				
N x M	NS	NS	NS	NS

WAS = Weeks after sowing, LS = Level of significance, SE = Standard error, * & ** = Significant @ 0.05 & 0.01 probability level, Means followed by the same letter in a column are statistically same by DMRT

Table 2: Effects of nitrogen fertilizer and ectomycorhiza on number of leaves of sorghum

Treatments	WAS 4	6	8	10
Nitrogen (kg/ha)				
0	6.11[b]	8.39[b]	9.86[b]	10.09[b]
30	7.45[a]	9.90[a]	12.46[a]	12.91[a]
60	7.05[a]	9.95[a]	12.17[a]	12.69[a]
LS	**	**	**	**
SE±	0.20	0.35	0.31	0.33
Mycorhyza				
Glomus spp	7.07	9.58[a]	12.41[a]	12.80[a]
Gigaspora spp	6.71	8.71[b]	11.58[b]	11.01[b]
LS	NS	*	**	*
SE±	0.16	0.27	0.24	0.37
Interaction				
N x M	NS	NS	NS	NS

WAS = Weeks after sowing, LS = Level of significance, SE = Standard error, * & ** = Significant @ 0.05 & 0.01 probability level, Means followed by the same letter in a column are statistically same by DMRT

Table 3: Effects of nitrogen fertilizer and ectomycorhiza on leaf area of sorghum

Treatment	WAS 4	6	8	10
Nitrogen (kg/ha)				
0	50.93[b]	183.96[c]	457.15[b]	463.09[b]
30	102.64[a]	492.22[b]	765.52[a]	761.33[a]
60	90.98[a]	426.91[a]	736.12[a]	741.41[a]
LS	**	**	**	**
SE±	7.78	16.32	31.37	31.00
Mycorhyza				

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Glomus spp	76.59	377.15[a]	664.52[a]	675.24[a]
Gigaspora spp	86.44	350.25[b]	641.34[b]	650.31[b]
LS	NS	**	*	*
SE±	6.35	7.32	7.62	7.31
Interaction				
N x M	NS	NS	NS	*

WAS = Weeks after sowing, LS = Level of significance, SE = Standard error, * & ** = Significant @ 0.05 & 0.01 probability level, Means followed by the same letter in a column are statistically same by DMRT

Table 4: Interaction of nitrogen fertilizer and ectomycorhiza on leaf area of sorghum at 10 weeks after sowing

	Mycorhiza	
Treatments	Glomus spp	Gigaspora spp
Nitrogen (kg/ha)		
0	391.45[c]	387.90[c]
30	673.08[b]	647.13[b]
60	784.23[a]	691.34[b]
LS	*	
SE±	29.30	

LS = Level of significance, SE = Standard error, * = Significant @ 0.05 probability level, Means followed by the same letter in a column are statistically same by DMRT

Table 5: Effects of nitrogen fertilizer and ectomycorhyza on stem girth, number of prop root and panicle length of sorghum

	Parameters		
Treatments	Stem Girth	Number of Prop root	Panicle Length
Nutrient Sources			
0	7.32[b]	14.05[b]	29.09[b]
30	10.32[a]	19.36[a]	45.44[a]
60	10.33[a]	19.70[a]	44.40[a]
LS	**	*	**
SE±	0.24	1.58	0.62
Mycorhyza			
Glomus spp	9.17	18.71[a]	39.37[a]
Gigaspora spp	9.47	16.03[b]	36.91[b]
LS	NS	*	*
SE±	0.20	0.81	0.51
Interaction			
N x M	NS	NS	NS

LS = Level of significance, SE = Standard error, * & ** = Significant @ 0.05 & 0.01 probability level, Means followed by the same letter in a column are statistically same by DMRT

Table 6: Effects of nitrogen fertilizer and ectomycorhyza on number of spikes, 1000grain weight and grain yield of sorghum

	Parameters		
Treatments	Number of Spikes	1000 Grain Weight	Grain Yield
Nitrogen (kg/ha)			
0	36.30[b]	21.70[b]	1730.82[b]
30	63.42[a]	30.69[a]	3423.06[a]
60	63.68[a]	31.36[a]	3461.25[a]
LS	**	**	**
SE±	0.73	0.50	85.01
Mycorhyza			
Glomus spp	58.60[a]	29.44[a]	3049.95[a]
Gigaspora spp	55.34[b]	27.39[b]	2693.47[b]
LS	**	*	**
SE±	0.90	0.41	69.41
Interaction			
N x M	NS	*	**

LS = Level of significance, SE = Standard error, * & ** = Significant @ 0.05 & 0.01 probability level, Means followed by the same letter in a column are statistically same by DMRT

Table 7: Interaction of nitrogen fertilizer and ectomycorhiza on 1000 grain weight and grain yield of sorghum

	Mycorhiza			
Treatments	Glomus spp	Gigaspora spp	Glomus spp	Gigaspora spp
Nitrogen (kg/ha)				
0	19.54[c]	20.91[c]	1391.45[c]	1387.96[c]
30	27.18[b]	28.13[b]	2673.08[b]	2647.13[b]
60	31.93[a]	29.24[b]	3484.13[a]	2891.34[b]
LS	*		**	
SE±	0.73		187.49	

LS = Level of significance, SE = Standard error, * & ** = Significant @ 0.05 & 0.01 probability level, Means followed by the same letter in a column are statistically same by DMRT