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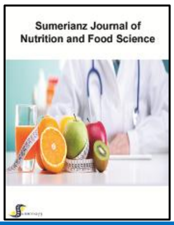

Original Article Open Access

Growth and Yield of Maize (*Zea Mays* L.) As Influenced by Some Indigenous Ectomycorhyza and Nitrogen Fertilizer in Bauchi State Nigeria

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Abstract

A field trial was conducted at the Abubakar Tafawa Balewa University, Bauchi to study the influence of nitrogen fertilizer and ectomycorhiza on the growth and yield of maize. The treatments consisted of two species of mycorhiza (*Glomus* and *Gigaspora spp*.) and three levels of nitrogen fertilizer (0, 60 and 120 kg/ha), 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, cob girth, cob weight, 100 grain weight and grain yield. All data collected were subjected to analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) was adopted to separate 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 120 kg N/ha was significantly (P=0.05) better than the other treatments in promoting growth and yield of maize. 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 maize. Study on the interaction revealed that, application of 120 kg N/ha to maize inoculated with *Glomus spp*. gave significantly (P=0.05) higher growth and yield than the other treatments combination. Based on the result of this findings, application of 120 kg N/ha to maize inoculated with *Glomus spp*. can be adopted by farmers in the study area.
Keywords: Maize; Fertilizer; Mycorhiza; Glomus spp. and Gigaspora spp.

1. Introduction

In Nigeria like most African countries agriculture is the dominant occupation which employed larger number of its people. Many sub-Saharan people practice rain-fed agriculture as means of living (Bekele *et al*., 2014). However, food insecurity and hunger is common with millions of people under threat (Bekele *et al*., 2014; Otaha, 2013). Food crisis is becoming a daily topic mainly due to threat imposed by vagaries of weather particularly decline in soil fertility and drought as a result of climatic change (Sasson, 2012; Zakari *et al*., 2014). Higher risk of desertification and nutrient mining due to continuous cultivation with little or no addition of fertilizer is projected to worsen the issue (Schmidhuber and Tubiello, 2007). A greater part of African soil was reported to lose its productivity as a result of continuous land degradation which imposed mostly by lack of organic matter, nutrient depletion and erosion. This coupled with rapid population growth leads to increased pressure and putting more lands under cultivation (Hrynkiewicz and Baum, 2011). This call for a need to curtail the vulnerable nature of sub-Saharan Africa through increasing crop yield under the current farming condition (Jha and Kumar, 2011). To achieve the said objective without damage to environment, crop adaptation and efficient soil fertility managements are the answer (Sharma *et al*., 2010). The use of microorganisms by means of biofertilization, especially mycorrhizal fungi that promote plant growth can serve the purpose (Rossi *et al*., 2007). Mycorrhizal association enhance water and nutrients absorption as well as increasing protection against soil born pathogens (Khurana and Singh, 2011). They form a mutualistic relationship with plant through which they obtain their nutrient from the plant and increase the efficiency with which the plant acquire water and nutrient from the soil (Sanon et al., 2010) leading to increase in crop productivity under low soil fertility (Millar and Ballhorn, 2013). The environmental condition however, play a key role in determining the effectiveness of this relationship (Millar and Ballhorn, 2013; Torres-Aquino et al., 2017). This trial was carried out to investigate the influence of nitrogen fertilizer and some indigenous ectomycorrhiza on the growth and yield of maize in Bauchi state, Nigeria.

2. Materials and Methods

Field trial 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 maize (variety; EVDT). The treatments consisted of two species of mycorrhiza (*Glomus* and *Gigaspora spp*.) and three levels of nitrogen fertilizer (0, 60 and 120 kg/ha), factorially combined to give a total of six treatments combination and laid out in a randomized complete block design (RCBD)

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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. Two seeds of maize were planted on the treated soils inside the bags and covered with the same soil and thinned to one stand per hill one week after emergence. Data was collected at biweekly interval on plant height, number of leaves, leaf area, stem girth, cob girth, cob weight, 100 grain weight and grain yield.

2.1. Data Analysis

All data collected were subjected to analysis of variance using statistical analysis system procedure (SAS, 2003) and Duncan's multiple range test (DMTR) was adopted in separating the means.

3. Results and Discussion

3.1. Influence of some Indigenous Ectomycorrhiza and Nitrogen Fertilizer on Growth Characters of Maize

3.1.1. Plant Height

The 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 120 kg N/ha was found to be significantly (P=0.05) better than the other treatments throughout the study period. The significant difference observed in this study indicated the importance of nitrogen fertilizer to the growth of maize. 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 crop. 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 maize. 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.

Table-1. Effects of nitrogen fertilizer and ectomycorhiza on plant height of maize

	WAS			
Treatments	2	4	6	8
Nitrogen (kg/ha)				
0	4.12^c	14.64^c	46.65^c	129.15^c
60	4.93^b	16.88^b	52.23^b	135.64^b
120	6.62^a	24.20^a	60.54^a	166.69^a
LS	**	**	**	**
SE±	0.23	0.49	1.61	2.15
Mycorhyza				
Glomus spp	5.62^a	20.38^a	57.12^a	146.82^a
Gigaspora spp	5.06^b	17.86^b	48.81^b	141.53^b
LS	*	**	**	*
SE±	0.17	0.83	2.13	1.71
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

3.1.2. Number of Leaves

Table 2 presented the result on effects of nitrogen fertilizer and ectomycorrhiza on number of leaves of maize. The result revealed a significant (P=0.05) difference among the treatments used throughout the study period. The result further indicated that, 120 kg N/ha produced statistically (P=0.05) higher number of leaves than 60 kg and 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, except at 2 and 4 WAS where no significant (P=0.05) difference was observed, *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 maize 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.

Table-2. Effects of nitrogen fertilizer and ectomycorhiza on number of leaves of maize

	WAS			
Treatments	**2**	**4**	**6**	**8**
Nitrogen (kg/ha)				
0	4.31[b]	7.69[c]	9.86[c]	11.19[c]
60	4.55[b]	8.80[a]	11.46[b]	14.81[b]
120	5.85[a]	10.35[a]	14.17[a]	16.56[a]
LS	**	**	**	**
SE±	0.19	0.35	0.34	1.03
Mycorhyza				
Glomus spp	4.07	8.58	12.43[a]	15.38[a]
Gigaspora spp	4.71	7.71	11.18[b]	14.07[b]
LS	NS	NS	**	*
SE±	0.26	0.37	0.25	0.41
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

3.1.3. Leaf Area

The result as presented in table 3 revealed that, there exist a significant (P=0.05) difference among the treatments used. The result also indicated that, application of 120 kg N/ha produced significantly (P=0.05) wider leaf than 60 kg and control 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 Musa *et al.* (2011); Sanginga *et al.* (2002) who reported that nitrogen has a significant contribution to vegetative growth of plants. Study on mycorrhizal inoculation revealed that, *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 120 kg N/ha to maize inoculated with *Glomus spp*. was found to be significantly (P=0.05) better than all the other treatments combination in terms of leaf area. The wider leaves observed under *Glomus spp*. indicated its superiority in promoting growth of maize to *Gigaspora spp*. It could also be due to the effects of mycorrhiza in helping the plant to acquire more nutrient from 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.

Table-3. Effects of nitrogen fertilizer and ectomycorhiza on leaf area of maize

	WAS			
Treatments	**2**	**4**	**6**	**8**
Nitrogen (kg/ha)				
0	73.42[c]	139.06[c]	247.45[c]	251.19[c]
60	94.94[b]	154.52[b]	256.56[b]	295.32[b]
120	136.78[a]	209.71	295.42[a]	327.94[a]
LS	**	**	**	**
SE±	7.08	5.12	3.02	13.10
Mycorhyza				
Glomus spp	106.59[a]	183.87[a]	275.52[a]	317.26[a]
Gigaspora spp	95.44[b]	161.65[b]	265.34[b]	298.37[b]
LS	**	**	*	*
SE±	3.35	7.22	3.32	5.31
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-4. Interaction of nitrogen fertilizer and ectomycorhiza on leaf area of maize at 6 weeks after sowing

	Mycorhiza	
Nitrogen (kg/ha)		
Treatments	Glomus spp	Gigaspora spp
0	231.45[c]	217.10[a]
60	273.18[b]	264.23[b]
120	304.15[a]	271.37[b]
LS	*	
SE±	4.31	

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

3.1.4. Stem Girth

Table 5 presented result of the effects of nitrogen fertilizer and ectomycorrhiza on stem girth of maize. 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, 120 kg N/ha gave statistically (P=0.05) thicker stem than the other treatments throughout the study period. This indicated the importance of fertilizer application in promoting stem girth of maize. The result of this study is in conformity with the result of Musa *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, *Glomus spp*. significantly (P=0.05) produced thicker stems than *Gigaspora spp*. This indicated that, mycorrhizal inoculation had significant effect on the stem girth of maize. The result of the present findings is in agreement with the report of Hrynkiewicz and Baum (2011) who reaffirmed that, ectomycorrhiza play a crucial role in biogeochemical cycling of ecosystems leading to increase in plant growth.

3.2. Influence of some Indigenous Ectomycorrhiza and Nitrogen Fertilizer on Yield and Yield Components of Maize

3.2.1. Cob Girth

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 120 kg N/ha produced statistically (P=0.05) thicker cob than the other treatments. 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) thicker cob than *Gigaspora spp*. The increase in cob girth as 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.

3.2.2. Cob Weight

Table 5 also presented the result on the effect of nitrogen fertilizer and ectomycorrhiza on cob weight of maize. The result revealed a significant (P=0.05) different among the treatments used. The result further indicated that, application of 120 kg N/ha produced statistically (P=0.05) heavier cobs than the other treatments and all the treatments were better than the control. The significant increase in cob weight as a result of nitrogen fertilizer application indicated the influence of fertilizer application on the yield components of maize. 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) heavier cobs of maize than *Gigaspora spp*. The significant increase in cob weight 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.

Table-5. Effects of nitrogen fertilizer and ectomycorhyza on stem girth, cob girth and cob weight of maize

	Parameters		
Treatments	Stem Girth	Cob Girth	Cob Weight
Nutrient Sources			
0	5.36^{c}	9.35^{c}	82.69^{c}
60	9.62^{b}	12.46^{b}	103.94^{b}
120	11.37^{a}	14.72^{a}	**
LS	**	*	7.62
SE±	0.54	0.72	
Mycorhyza			
Glomus spp	12.17^{a}	14.82^{a}	118.47
Gigaspora spp	10.67^{b}	12.43^{b}	113.81
LS	**	*	NS
SE±	0.45	0.61	2.51
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

3.2.3. 100 Grain Weight (g)

The result as presented in table 6 revealed a significant (P=0.05) difference among the treatments used. The result further showed that, 120 kg N/ha was found to be significantly (P=0.05) better than all the other treatments in terms of heavier grains of maize. Result of the interaction (Table 7) on the other hand revealed that, application of 120 kg N/ha to maize 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 maize root. The result of this findings lend support to the report of Musa *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.

3.2.4. Grain Yield (kg/ha)

Effects of nitrogen fertilizer and ectomycorrhiza on grain yield of maize are 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, application of 120 kg N/ha produced statistically (P=0.05) better grain yield than 60 kg which is significantly (P=0.05) better the control. The result of the interaction (Table 7) of nitrogen and ectomycorrhiza revealed that, application of 120 kg N/ha to maize inoculated with *Glomus spp*. gave significantly (P=0.05) higher yield of sorghum than the other treatments combination used. However, all the treatments were better than the control in promoting grain yield. The increase in yield with nitrogen fertilizer application as observed in this study clearly indicates the importance of inorganic fertilizer in the performance of maize. 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 maize. 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.

Table-6. Effects of nitrogen fertilizer and ectomycorhyza on 100 grain weight and grain yield of maize

Parameters		
Treatments	100 Grain Weight (g)	Grain Yield (kg/ha)
Nitrogen (kg/ha)		
0	18.72^{c}	1370.93^{c}
60	22.29^{b}	3527.36^{b}
120	28.86^{a}	5481.59^{a}
LS	**	**
SE±	1.14	581.32
Mycorhyza		
Glomus spp	27.49^{a}	6028.12^{a}
Gigaspora spp	23.38^{b}	5487.28^{b}
LS	*	**
SE±	1.21	168.49
Interaction		
N x M	*	**

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 100 grain weight and grain yield of maize

Mycorhiza				
100 grain weight (g)			**Grain yield (kg/ha)**	
Treatments	Glomus spp	Gigaspora spp	Glomus spp	Gigaspora spp
Nitrogen (kg/ha)				
0	18.47^{c}	17.94^{c}	2391.33^{e}	2317.16^{e}
60	25.12^{b}	26.13^{b}	4674.81^{c}	4347.63^{d}
120	29.36^{a}	27.14^{b}	6085.35^{a}	5792.54^{b}
LS	*		**	

SE±	0.63		97.19	

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

4. Conclusion and Recommendation

In conclusion however, 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 maize cannot be overemphasized. Growth and yield of maize was observed to increase with mycorrhizal inoculation irrespective of the level of nitrogen application. Based on the result of this findings, application of 120 kg N/ha to maize inoculated with *Glomus spp*. of mycorrhiza can be recommended for maize production in the study area.

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Conflict of Interest Declaration

The authors of this article declared that, no conflict of interest exist.

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