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Evaluation of the influence of arbuscular mycorrhizal and organo-mineral fertilizer on productivity of Okra

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Abstract

The influence of *Glomus clarum* and organomineral fertilizer on productivity of Okra was studied in a field experiment conducted in National Horticulture Research Institute (NIHORT) Ibadan. The experimental design was randomized complete block design (RCBD). There were seven treatments which were replicated three times. The arbuscular mycorrhiza fungi (AMF) and organomineral fertilizer (OMF) were applied into 6 kg soil at the rate of 5, 10 and 15 g each per plant, while the control had 0 g. The result showed that the yield of plants treated with 5 gAM fungi produced highest cumulative number of harvested fruit (2.17) and harvested weight per fruit (7.71 g/plant) while, plants treated with 10 g OMF and 5 gAM fungi produced higher cumulative harvested fruit number which were not significantly different from each other. The fruit yield of Okra was optimized with 5 gAM fungi.

Keywords: *Glomus clarum*, organomineral, productivity, fertilizer, yield.

INTRODUCTION

Okra, *Abelmoschus esculentus* L. is an important vegetable grown as an annual crop in tropical Africa and sub-tropical part of the world for its fibrous fruits or pods containing round mature white seeds and leaves. The plant has erect and robust green stem which may be tinged red with variable branches and a deep tap root (Awosusi, 1989). Okra production in Nigeria either sole or in crop mixture has increased due to its high nutritional value. It provides important source of protein, vitamin A and C, carbohydrate, calcium, potassium, magnesium and other minerals which are often lacking in the diet of people. As a valuable medicinal plant, it is used in treatment of peptic ulcer and as source of plasma replacement in man's body fluid. Also, both mature pods and stem contain fiber which can be used industrially in manufacture of paper, rope, jute suck and rug. Okra thrives well on all types of soil. The best performance of okra is obtained on well manure loamy soil and can also be cultivated along river valleys during the dry season (Adeoye, 1987).

Generally, some of the major constraints identified to be responsible for low production of vegetable crops include poor soil fertility, high cost and unavailability of inorganic fertilizer, difficulty in obtaining adequate amount for large scale agriculture and delay in the release of the essential mineral nutrients for immediate use of the plant (Olawuyi et al., 2010).

The use of organic manure has been applied to soil by farmers in the past, but with the introduction of mineral fertilizers such as NPK, ammonium sulphate, nitrate of potash and super-phosphates, the use of organic manure have almost been abandoned in favour of these man-made fertilizers. The benefits derived from organic fertilizers include; reduction in the impact of leaching on the soil, improvement in physical and chemical properties of the soil, conservation of soil moisture, improvement in soil aeration, soil fertility, crop production, environmental sanitation and increase in organic matter content of the soil (Agboola and Omueti, 1982).

Although, there is a point at which indiscriminate use of these fertilizers without usual soil testing to ascertain the type and dosage required constitute inherent hazards to the soil chemical composition, waste of resources, retarding plant growth and fruit production (Igbinnosa et al., 1992). Alternative to the use of organo-mineral fertilizer which is environmental friendly, readily available and cheap for a common farmer should be developed. This suggests the use of arbuscular mycorrhizal fungi (AMF), *Glomus clarum.* Symbiotic associations between AMF and plant roots are widespread in the natural environment and can provide a range of benefits to the host plant (Gosling et al., 2005). Mycorrhizal fungi play important roles in nutrition and fitness of plants. They contribute to soil nutrient uptake, soil aggregation, soil formation and enhance root absorption area (Gemma et al., 1997; Smith and Read, 1997). They contribute to overcoming mineral element deficiencies, improve plant ability to use the soil resources and improve plant performance (Mc Gonigle, 2001; Abbott and Robson, 2006). Douds and Reider (2003) also reported that inoculation of soil with AMF increases the yield of green peppers. So far, literatures have shown that, there is little information on comparison between organic and inorganic fertilizer sources as it affects productivity of okra.

The objective of this study therefore was to evaluate the influence of arbuscular mycorrhizal and organo-mineral fertilizer on productivity of Okra.

MATERIALS AND METHODS

The field experiment was conducted for two years (2009 and 2010) at the experimental farm of the National Horticultural Research Institute (NIHORT) Ibadan, Nigeria. The farm is situated at Longitude 3° 21°E and Latitude 7° 25°N and altitude of approximately 2800 mm above sea level, temperature and humidity on the average of 28°C and 85% respectively in the southern guinea savanna ecological zone of Nigeria (Olakojo and Olaoye, 2007). The land measuring 21.5 m × 10.5 m was prepared mechanically by ploughing twice and harrowing once to have good soil structure. The plot has a dimensional size of 3 m × 1.5 m with 0.5 m margin round each plot. Samples of top soil (0 to 30 cm depth) were taken randomly from the experimental farm, air-dried, sieved through a 2 mm sieve and analyzed for their physical and chemical properties using standard procedures described by Black (1965). The treatments consisted of three arbuscular mycorrhizal fungi (AMF) (5, 10, 15 g/plant) and three organo-mineral fertilizers (OMF) (5, 10, 15 g/plant) while, the control (0g/plant) was not treated. Factorial combination of the treatments was laid out in a randomized complete block design with three replications.

The mycorrhizal fungi; *Glomus clarum* were multiplied for increase using available inocula source collected from the department of Botany and Microbiology, University of Ibadan, Nigeria. This consists of mixture of chopped root of the trapping plant hyphae, spores and soil fragments. Three seeds of “V-35” variety of Okra obtained from seed store of the Institute of Agricultural Research and Training (I A Rand T), Moor Plantation Ibadan were sown per hole two weeks after land preparation at 30 cm × 50 cm inter and intra spacing. They were later thinned to two per stand two weeks after sowing. All agronomic practices were duly carried out. Four plants were randomly selected and tagged from each plant on one plot for data collection.

Data on growth parameters collected at 3, 4, 5, 6, 7 weeks after planting were plant height (cm), number of leaves per plant, and stem girth (mm). Three successive harvesting were carried out at weekly interval. Yield parameters taken at each harvest include; number of harvested fruit per plant and weight of harvested fruit per plant (g). Soil samples were also taken for post harvest analysis to ascertain its nutrients contents. Data were subjected to statistical analysis of variance (ANOVA) with F- test for significant differences of the treatments using statistical analysis system (SAS) software version 5 of general linear model (GLM), while differences among mean of the treatments were separated using Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Duncan,1955).

RESULTS AND DISCUSSION

Physical and chemical properties of pre and post planting soil analysis on Ca, Mg, Na, K, P, and pH

The physical analysis of the soil used for this experiment revealed that it contained 18.5% sand, 11.6% clay and 69.96% silt. The soil pH was acidic with pH value of 5.7. The available phosphorous (P) level in the soil was 8.14 mg/kg. Calcium (Ca) content of the soil was significantly lower (0.43) compared with the control. Arbuscular mycorrhizal (AMF) showed the tendency of increasing the pH level of the soil. Phosphorus uptake by AM at all levels for plant use was significantly lower than other treatments but not significantly different from control. Na, K, Mg in pre-planting soil was significantly different from the control while, Ca and P values before planting were not significantly different from control.

The value of calcium content on the post harvest soil treated with 5 g/plantAMF recorded highest significant value (1.79) which was different from other treatments but similar to 5 g/plant OMF while, the calcium values of 10 g/plant for both AMF and OMF were not significantly different from each other. Similar observation was also reported by George et al. (1992).

Magnesium (Mg) value from 10 g/plantAMF and 10 g/plantOMF treatments were highest for post-harvest soil analysis and different from other treatments but not significantly different from 5 g/plantAMF treatment. Sodium (Na) value was significantly lower (0.28) in 15 g/plantAMF applied soil than other treatments. The potassium (K) value was significantly higher in 15 g/plant AMF (0.33) than 15 g/plant OMF (0.17). Phosphorous was significantly higher in all AMF treated soils than other OMF treatments and control.

Lower values of P were observed in all the AMF treated soils relative to OMF treatments but significantly higher than the value in control soil (Table 6). This proved the

Table 1. Effect of arbuscular mycorrhizal fungi and organomineral fertilizer on number of leaves of Okra (mean of two years).

Treatment (g/plant)	3WAP	4WAP	5WAP	6WAP	7WAP
Control	2.70^{c}	3.87^{c}	4.43^{bc}	4.60^{bc}	4.77^{b}
5 g of AMF	5.13^{b}	6.00^{b}	7.60^{a}	6.77^{a}	7.43^{a}
10 g of AMF	5.50^{ab}	6.80^{ab}	6.60^{ab}	4.80^{bc}	4.17^{bc}
15 g of AMF	6.00^{a}	7.20^{a}	6.93^{ab}	6.43^{a}	5.27^{ab}
5 g of OMF	5.20^{b}	5.87^{bc}	5.77^{b}	6.21^{ab}	4.87^{b}
10 g of OMF	4.53^{bc}	$5.90b^{c}$	5.10^{b}	5.60^{b}	4.37^{bc}
15 g of OMF	5.20^{b}	6.10^{b}	5.60^{b}	6.20^{ab}	4.13^{bc}

Mean with the same letter in the same column are not significantly different P≤0.05 according to the Duncan multiple range test. AMF - Arbuscular mycorrhizal fungi, OMF-Organo-mineral fertilizer WAP = Weeks after planting.

Table 2. Effect of arbuscular mycorrhizal fungi and organo-mineral fertilizer on plant height (cm) of Okra (mean of two years).

Treatment (g/plant)	3WAP	4WAP	5WAP	6WAP	7WAP
Control	5.33^{bc}	7.23^{d}	9.03^{c}	11.47^{c}	12.73^{bc}
5 g of AMF	10.17^{ab}	16.50^{ab}	20.90^{ab}	23.57^{ab}	26.40^{a}
10 g of AMF	11.43^{a}	15.30^{b}	18.27^{bc}	21.03^{bc}	22.23^{ab}
15 g of AMF	11.53^{a}	17.27^{ab}	22.57^{a}	24.70^{ab}	25.67^{a}
5 g of OMF	9.93^{b}	14.03^{bc}	18.17^{bc}	20.60^{bc}	22.03^{ab}
10 g of OMF	10.03^{ab}	14.57^{bc}	19.60^{b}	22.27^{b}	23.30^{ab}
15 g of OMF	11.17^{a}	19.10^{a}	20.27^{ab}	29.63^{a}	20.90^{b}

Mean with the same letter in the same column are not significantly different (P≤0.05) according to the Duncan multiple range test. AMF- Arbuscular mycorrhizal fungi, OMF-Organo-mineral fertilizer; WAP = Weeks after planting

ability of AM to encourage absorption/uptake of P in the soil as earlier reported by Smith and Read (1997) which stated that AM are very effective in helping the plants to absorb P from the soil and invariably prevents P runoff that leads to eutrophication (undesired biological growth and productivity). Increased phosphorous uptake by mycorrhizal plants can help to reduce the quantity of this nutrient to be added to the soil, and decrease the accumulated phosphorous soil and water.

Akinsanmi (1996) similarly observed that NPK fertilizer also increased phosphorous level in the post harvest soils and might cause phosphorous pollution in the environment because P is an immobile nutrient and it is susceptible to fixation by certain chemical agent such as aluminum and iron. Sometimes large quantities of phosphorous may be present in the soil but not available to the growing plants because it is insoluble.

Growth and yield parameters

There were no significant difference in the number of leaves produced per plant among the plants treated with 5 g of AMF, 5 g of OMF, and 15 g of OMF at 3 weeks after planting (3WAP) while, plants treated with 5 g of AMF and 15 g of OMF as well as 5 g of OMF and 10 g of OMF were not significantly different from each other at 4 weeks after planting (4WAP). 15 g of AMF at 3, 4, 6 weeks and 5 g of AMF at 5, 6 and 7 weeks after planting produced the highest number of leaves and significantly different from other treatments (Table 1). Again, plant treated with 5 g of AMF and 15 g of AMF at 7weeks after planting produced plant height which did not differ from each other but significantly different from other treatments and control (Table 2). The treatments also produced significant higher plant height than the control plants at 3, 4, 5, 6 and 7 WAP respectively (Table 3). Plants treated with 5 g of AMF, 10 g of AMF, 15 g of AMF and 15 g of OMF (3WAP), 10 g of AMF, 15 g of AMF, and 10 g of OMF (4WAP), 10 g of AMF, 5 g of OMF and 15 g of OMF (5WAP), 10 g of AMF, 15 g of AMF and 15 g of OMF (6WAP) and 10 g of AMF,15 g of AMF, 10 g of OMF and 15 g of OMF (7WAP) were not significantly different from one another with respect to the stem girth of Okra plant. Both the OMF and AMF treatments were significant from each other with exception of the lowest treatments

Table 3. Effect of arbuscular mycorrhizal fungi and organo-mineral fertilizer on the stem girth of Okra (mm) (mean of two years).

Treatment (g/plant)	3WAP	4WAP	5WAP	6WAP	7WAP
Control	0.62^{bc}	0.74^{bc}	0.96^{bc}	1.13^{bc}	1.37^{bc}
5 g of AMF	1.87^{b}	1.93^{b}	2.13^{b}	3.03^{a}	3.36^{a}
10 g of AMF	1.97^{b}	2.33^{a}	2.40^{ab}	2.57^{ab}	2.77^{ab}
15 g of AMF	1.83^{b}	2.33^{a}	2.53^{a}	2.59^{ab}	2.89^{ab}
5 g of OMF	1.80^{b}	2.03^{ab}	2.24^{ab}	2.33^{b}	2.45^{b}
10 g of OMF	2.07^{a}	2.30^{a}	2.43^{a}	2.38^{b}	2.73^{ab}
15 g of OMF	1.77^{b}	2.15^{ab}	2.35^{ab}	2.42^{ab}	2.67^{ab}

Mean with the same letter in the same column are not significantly different (P≤0.05). AMF = Arbuscular mycorrhizal fungi; OMF- Organo-mineral fertilizer; WAP = Weeks after planting.

Table 4. Effect of arbuscular mycorrhizal fungi and organomineral fertilizer on harvested fruit number of Okra plant (mean of two years).

Treatment (g/plant)	IHF No	2HF No	3HF No
Control	0.23^{cd}	0.33^{bc}	0.27^{c}
5 g of AMF	2.89^{b}	1.67^{a}	1.97^{a}
10 g of AMF	3.33^{ab}	1.47^{ab}	0.33^{bc}
15 g of AMF	3.67^{ab}	1.00^{b}	0.67^{b}
5 g of OMF	2.33^{bc}	1.33^{ab}	1.00^{ab}
10 g of OMF	4.00^{a}	0.67^{bc}	1.77^{a}
15 g of OMF	1.67^{c}	1.60^{a}	0.67^{b}

Mean with the same letter in the same column are not significantly different (P ≤0.05) according to the Duncan multiple range test. AMF = Arbuscular mycorrhizal fungi; OMF- Organo-mineral fertilizer; HFNo: Harvest fruit number.

rate of 5 g / plant of AMF and OMF (3WAP) and 5 g/ plant of AMF and 15 g of AMF (4WAP) that were not significantly different from each other in number of leaves produced. This supported the view of Olawuyi et al. (2010) and Schippers, (2000) which reported the contribution of nitrogen sources in promoting the vegetative portion of the plant, producing large green leaves, and also necessary for dropping of fruits.

Mean number of fruits produced per Okra plant grown with 5 g of AMF was found to be the highest (2.18) among all the treatments. This was similar to 15 g of OMF but significantly different from those recorded from plant treated with 10 and 15 g per plant for both AMF and OMF, and control plants, while treated plants with 15 g of AMF and OMF were not significantly different from each other (Table 4). This confirmed the work of Bamidele (2000) that an increase in the yield of cucumber as the NPK rate increases from 200 to 400 kg/ha. This however disagreed with the findings of Glumtsov et al. (1975) who reported a depression in cucumber yield as the NPK rate increased.

With respect to the harvested weight of fresh fruit of Okra per plant, those that were treated with 5 g of AMF produced significantly mean highest yield per plant compared with the other treatments in this experiment, (7.71 g/plant) (Table 5). Akinsanmi (1995) revealed that phosphorous is essential for flowering and fruits formation. However, large quantities of phosphorous sometimes may be present in the soil but not available to the growing plant because it may be insoluble in such situation.

Conclusion

The results showed that plant treated with 5 g/plantAM fungus produced higher mean cumulative weight of harvested fruits (7.71 g/plant) which was significantly different from other treatments. Also, among the treatments with Organo-mineral fertilizer, the highest mean cumulative yield of 4.75 g/plant was obtained from plant treated with 15 g/plant OMF. The use of 5 g/plant AM fungus can be recommended for farmers since most agricultural crops can perform better and more productive when well colonized by AM fungus, especially in the cultivation of Okra. The farmers should be encouraged to use AMF as it is environmentally friendly, required no specialized skill for its application and there is no need of frequent application as it is in the case of chemical fertilizers.

Table 5. Effect of arbuscular mycorrhizal fungi and organomineral fertilizer on harvest weight per fruit of Okra (mean of two years).

Treatment (g/plant)	IHWF	2HWF	3HWF
Control	3.93[d]	0.67[d]	0.67[d]
5 g of AMF	14.47[a]	4.67[a]	3.80[a]
10 g of AMF	10.37[b]	3.33[bc]	1.27[cd]
15 g of AMF	12.87[ab]	4.00[ab]	2.10[bc]
5 g of OMF	8.77[c]	3.77[b]	1.67[c]
10 g of OMF	9.87[bc]	1.50[cd]	2.77[b]
15 g of OMF	7.87[cd]	2.89[c]	3.50[ab]

Mean with the same letter in the same column are not significantly different (P≤0.05) according to the Duncan multiple range test. AMF = Arbuscular mycorrhizal fungi; OMF-Organo-mineral fertilizer; HWF- Harvest weight per fruit.

Table 6. The result of pre and post planting soil analysis on Ca, Mg, Na, K, P and pH (mean of two years).

Treatment	Ca(cmolkg^{-1})	Mg(cmolkg^{-1})	Na(cmolkg^{-1})	K(cmolkg^{-1})	P(mgkg^{-1})	PH
Pre-planting	0.43[c]	0.38[a]	0.36[b]	0.31[a]	8.14[cd]	5.70
Control	0.79[bc]	0.18[bc]	0.41[ab]	0.19[b]	8.67[cd]	5.91
5 g/plant AMF	1.79[a]	0.34[a]	0.48[a]	0.24[ab]	12.11[c]	6.29
10 g/plant AMF	1.58[ab]	0.36[a]	0.47[a]	0.24[ab]	13.22[bc]	6.11
15 g/plant AMF	0.88[bc]	0.25[b]	0.36[b]	0.33[a]	14.92[b]	6.17
5 g/plant OMF	1.69[a]	0.31[ab]	0.46[a]	0.19[b]	19.73[ab]	6.02
10 g/Plant OMF	1.58[ab]	0.36[a]	0.41[ab]	0.22[ab]	20.74[a]	5.8
15 g/Plant OMF	1.23[b]	0.26[b]	0.28[bc]	0.17[b]	22.17[a]	5.84

Means with the same letter in the same column are not significantly different (P≤0.05). AMF = Arbuscular mycorrhizal fungi OMF-Organo-mineral fertilizer.

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