

Effect of *Arbuscular mycorrhizea*(AM), poultry manure(PM), NPK fertilizer and the combination of AM-PM on the growth and yield of okra (*Abelmoschus esculentus*)

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Abstract: Five accessions of *Abelmoschus esculentus*, obtained from two research and academic institution in Nigeria were used to access the effect of *Arbuscular mycorrhizea* (AM), Poultry Manure (PM), Inorganic fertilizer (NPK), and the synergy of *Arbuscular mycorrhizea* (AM) and Poultry Manure (PM) on the growth and yield of okra. This experiment was a 5 x 5 factorial, laid out in a Randomized Complete block design with 5- replications. The experiment was a pot experiment carried out at the Babcock University horticultural garden (rain forest ecology). This experiment was carried out during the late planting season of November 2011 to January 2012. Data were collected on nine yield related characters. The combined Analysis of Variance showed significance treatment, accession, replication and accession x treatment interaction effects on majority of the trait evaluated at 0.01 and 0.05 probabilities. Combination of AM-PM treatment produced a significantly high results in the traits observed though not significantly different from NPK treatment result in all traits, implying that AM-PM treatment can conveniently replace NPK in the growth and yield of okra. There was a significant positive correlation between plant height, leaf area, fruit width at maturity, pod weight and seed weight in okra. Bab okr3 and NH.Cb/07/008 performed well in pod weight per plant and fruit length at maturity and would make good putative parent for selection in an okra hybridization program.

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Introduction

Abelmoschus esculentus, commonly known as okra is a plant species in the family Malvaceae. Joshi and Hardras (1953) as cited by Nwangburuka et al (2011) reported that *A. esculentus* is an amphidiploid of *A. tuberculatus* (2n=58) and *A. ficulneus* (2n=72). Its fruit and leaves produce a sticky, mucilaginous sap that can be used as a soup thickener (Nwangburuka 2010). Okra is a tropical plant that is grown as an annual vegetable. Fresh okra fruit contains 2.1g protein, 0.2g fat, 8g carbohydrate, 36g calories, 1.7g fiber, 175.2 mg minerals, 232.7 vitamin and 88ml of water per 100g of edible portion (Berry et al., 1988; Siemonsma and Kouame, 2004). Okra has huge potential in the enhancement of livelihood of stakeholders in both rural and urban areas (NAP, 2006). It has been used as blood plasma replacement or blood volume expander (Siemonsma and Kouame, 2004).

Production and yield in crops, including okra has been confronted with challenges which include poor cropping system, poor soil fertility, activities of pest and diseases, poor planting genotypes amongst others (Manyong 2001 and 2002). However poor soil

productivity status has accounted for high poor performance in crops (Manyong, 2002). Donova and Casey (1998) reported that constant nutrient replenishment in the soil through the use of fertilizers, or sustainable agronomic practices, soil nutrient decline will be continuous. Currently, the increase in the demands for inorganic fertilizer to ameliorate the soil nutrient status and enhance crop production is high. Though, inorganic fertilizer releases their nutrient at a quicker rate, they are also associated with increase in soil acidity, soil chemical-concentration, increase in greenhouse gasses as well as induce cytological defects in crop cells (FAO, 2010, and Tabur and Oney 2009). In addition, the cost of inorganic fertilizer is becoming increasingly high, resulting in high cost of production. These side effects of the use of inorganic fertilizer have led to a shift in paradigm. Today, there is an advocacy for the use of organic fertilizer in agriculture (FAO 2010).

Therefore it is important to apply organic fertilizer on annual basis for optimum yield of vegetables. Hemeng et al., (1993) reported that organic manure is the best form of organic fertilizer for crop production. Olayinka (1996), Ismail et al.,

(1996) and Olayinka et al., (1998), resolved that the use of poultry manure as organic amendment significantly improved the physio-chemical and morphological properties of the soil. However, the use of organic manure has been associated to disease incidences in crops since the manure themselves harbour pathogen residues. Bio-fertilizers have also been considered as alternative source of soil amendment. Bio-fertilizers are natural and organic fertilizers that help to keep in the soil all nutrients and live micro-organisms required for the benefit of the plant. Olawuyi et al., (2011) reported that mycorrhizae has a symbiotic relationship with plant roots and that every plant has its own specific fungi which relates with it in nature. Recent study by Olawuyi et al., (2011) indicate that, only significantly high treatment rates (1200kg/ha) of *Arbuscular mychorrhiza*, singly produced significant increase in cucumber yield comparable to that of NPK fertilizer. Poultry manure on the other hand, promotes and enhances the growth and yield of vegetables plant but not all micro and secondary nutrients (most especially phosphorous) are readily available for the plant uptake, and this could bring about slow growth and poor yield

This study seeks to explore the potential of the synergy between *Arbuscular mychorrhiza* fungi and Poultry manure in the production and yield of okra as a means of developing alternative to inorganic fertilizer.

Materials and Methods

This experiment was a pot experiment conducted at Babcock University Horticultural Garden situated in the south west of the tropical rain forest ecology, in Nigeria. It was carried out during the late planting season of November 2011 to January 2012.

Five okra genotypes obtained from two teaching and research institutes namely Babcock University (BU) and National Centre for Genetic Resources and Biotechnology (NACGRAB) were used for this study (Table 1). Arbuscular Mycorrhizae fungi(AM) was obtained from the Department of Biosciences and Biotechnology, Babcock University. The AM was a silty-sand inoculum of *Glomus mossea* (20g of soil inoculum contains approx. 100 spores of *G. Mossea*)

Wet poultry manure was collected from the Babcock University poultry and was sun-dried to a reasonable moisture content of about 13% while the inorganic fertilizer used was NPK compound fertilizer (12:12:17) obtained from the Department of Agriculture, Babcock University. The trial was a 5 x 5 factorial, laid out in a Randomized Complete Block Design replicated five times. Each replication consists of a single pot. Seeds from each accession were sown at the rate of two seeds per pot, which was later thinned down to one seed per pot.

Data collected were in five different treatment levels.

- A. Control (without any treatment)
- B. 7.71gNPK/ha⁻¹ in 10kg of soil
- C. 3.86kgAM /ha⁻¹+3.86PM/Ha in 10kg of soil
- D. 7.71kgPM/ha⁻¹ in 10kg of soil
- E. 7.71kgAMF/ha⁻¹ in 10kg of soil

Table 1: Seed accessions and their sources.

Accessions	Stem texture	Fruit texture	source
Nh.cb/07/008	Smooth	Smooth	NACGRAB
Bab okr2	Rough	Hairy	BU
Nh.gb/07/017	Hairy	Spiny	NACGRAB
Bab okr3	Smooth	Hairy	BU
Bab okr4	Hairy	Smooth	BU

BU: Babcock University Ilishan-Remo, Ogun state, Nigeria.

NACGRAB: National Center for Genetic Resources and Biotechnology, Ibadan, Nigeria.

Each pot was filled with 10kg of garden soil with 50cm spacing between pots. Planting was done during the late planting season of November 2011. Seeds were sown at depths of 1cm. *Arbuscular mychorrhizae* and poultry manure were applied on the day of planting while NPK fertilizer was applied 2 weeks after planting. Weeding inside and around the pots were done manually at 3 weeks interval.

Soil and poultry manure analysis.

Soil and poultry manure samples were taken for routine chemical analysis in the laboratory using IITA, 1979 standard method and the result is shown in table 2.

Data was collected on the following qualitative and quantitative traits.

Qualitative

- Stem texture – by feeling/by touch

- Fruit pubescence – by touch
- Quantitative
- Plant height (was taken at flowering and at maturity)(cm)
 - Fruit length at maturity (cm)
 - Fruit width at maturity(cm)
 - Leaf area (length x width) (was taken at flowering and at maturity)(cm²)
 - Stem width at maturity(cm)
 - Pod weight per plant (g)
 - Seed weight per plant(g)

Table 2: Chemical analysis of soil and poultry manure

sample	%N	%P	%Ca	%Mg	%K	ppmNa	ppmMn	ppmFe	ppmCu	ppmZn
PM	3.02	2.00	4.98	0.53	1.98	32.23	157.28	194.95	6.48	44.31
Soil	0.217	7.61	2.00	0.46	0.17	0.10	73.88	57.15	1.36	8.61

Data Analysis

Data collected was analyzed using SAS Microsoft windows 80 (SAS institute 1999) employing the method outlined by Steel and Torrie (1980). Means were separated using Duncan multiple range test (DMRT).

Result and Discussion

Mean Square from combined analysis of variance of nine agronomic and yield characteristics of *A. esculentus*.

The mean square from combined analysis of variance of nine agronomic and yield related characters is shown in Table 3. The result revealed significant treatment effect in all the nine agronomic characters studied at 5% and 1% probability. Similarly there was significant accession effect in all characters except in stem width at maturity, fruit length at maturity and fruit width at maturity. There was also significant treatment accession interaction effect in stem width at maturity, leaf area at flowering and leaf area at maturity, the remaining characters are not significant. Similarly, there was no significant replication effect in all the characters studied. This result implies that the treatment affected significantly the expression of the traits in the accession. It further suggests variability in the accessions enough for crop improvement.

Mean performance of the accession in the nine agronomic characters under the treatments applied.

Table 4: shows the mean performance of the accession in nine agronomic characters under the treatments applied. The result shows that plant height at flowering ranged between 47.88cm and 37.48cm. Plant height at flowering was the highest with Am-Pm treatment (47.88) followed by treatment with NPK (45.28), though not significantly different from each other, the least plant height at flowering was recorded in control (37.48). Similarly, plant height at maturity ranged from 55.32 to 39.76. This value was highest in NPK (55.32).

Table 3: Means Square from combined analysis of variance of nine agronomic and yield characteristics of *A. esculentus*(okra)

Source of variance	df	Plant height at flowering	Plant height at maturity	Stem width at maturity	Leaf area at flowering	Leaf area at maturity	Fruit length at maturity	Fruit width at maturity	Pod weight per plant	Seed weight per plant
Trt	4	391.25*	1103.62*	0.64**	136211.11**	177243.17**	54.42**	3.24**	247.31**	60.71**
Acce	4	2925.07*	3040.82*	0.04 ^{ns}	42912.59*	54795.64*	13.36 ^{ns}	1.28 ^{ns}	42.67**	13.39**
Rep	4	78.45 ^{ns}	126.12 ^{ns}	0.03 ^{ns}	1507.94 ^{ns}	2918.04 ^{ns}	2.03 ^{ns}	0.72 ^{ns}	23.76 ^{ns}	5.12 ^{ns}
Trt*acc	16	77.83 ^{ns}	160.75 ^{ns}	0.04*	12081.72*	13828.97*	4.20 ^{ns}	0.24 ^{ns}	8.82 ^{ns}	2.02 ^{ns}
Error	96	67.83 ^{ns}	80.23 ^{ns}	0.01 ^{ns}	1534.13 ^{ns}	2148.38 ^{ns}	2.50 ^{ns}	0.35 ^{ns}	5.64 ^{ns}	1.94 ^{ns}
Total	124						25.35			
Cv(%)		19.02	18.41	14.50	27.60	27.84		26.17	34.08	40.71

Key: *Significant at 0.05, **Significant at 0.01, ns=Not Significant, df= degree of freedom, Trt= treatment, Acce= accession

TABLE 4: Combined mean performance of *A. esculentus* under different treatment for nine agronomic characters.

Treatment	Plant height at flowering	Plant height at maturity	Stem width at maturity	Leaf area at flowering	Leaf area at maturity	Fruit length at maturity	Fruit width at maturity	Pod weight per plant	Seed weight per plant
Am	41.52bc	45.04b	0.70b	100.80c	121.15b	5.51b	2.05bc	4.84bc	2.40bc
Pm	44.12ab	48.19b	0.74b	77.16d	96.65c	5.85c	2.29ab	5.81b	2.74b
Ampm	47.88a	54.96a	0.85a	204.38b	253.21a	7.71a	2.56a	9.72a	5.00a
Npk	45.28ab	55.32a	0.90a	238.01a	262.30a	7.77a	2.61a	10.84a	5.18a
Control	37.48c	39.76c	0.48c	89.26cd	95.27c	4.36c	1.74c	3.63c	1.81c

Keys: means with the same letter along the column are not significantly different from one another was not significantly different from Am-Pm (54.96) and lowest in control (39.76) this suggests that AM-PM produced similar effect in plant height compared to NPK, and may be able to replace NPK. This result agrees with the work of (Olawuyi et al 2011), working on the effect of AM and NPK singly applied on cucumber. Stem width at maturity was highest with NPK (0.90) but was not significantly different from Am-Pm (0.85) treatment, the least stem width at maturity was recorded in control (0.48). However leaf area ranged from 238.01cm to 77.16cm, the highest value was observed in NPK (238.01) which was not significantly different from Am-Pm (204.38) and the lowest value was recorded in Pm (77.16) this agrees with the work of Olawuyi et al; (2011) who reported a low performance of cucumber, at low concentration of AM alone. The concentration of AM-PM, has improved the absorption of nutrient capacity of accessions making available sufficient nutrients for crop (McGoningle, 2001, Abbott and Robson, 2006). Leaf area at maturity was highest at NPK (0.89) but was not significantly different from Am-Pm (0.85), control (0.49) was the lowest. Fruit length at maturity was significantly highest for NPK (7.77), and Am-Pm (7.71). This was followed by Pm (5.85) and Am (5.51). The lowest value in fruit length at maturity was observed in control (4.36). Fruit width at maturity ranged between 2.61 to 1.74 with NPK recording the highest value (2.61) which was not significantly different from Am-Pm (2.56) and the lowest record for this character was control (1.74). Similarly, pod weight per plant was highest with NPK treatment (10.84g), but was not significantly different from Am-Pm (9.72g) and the lowest was control (3.63g). However seed weight ranged between 5.18g and 1.81g, the value was highest in NPK treatment (5.18g), but was not also significantly different from the Am-Pm treatment (5.0g), control was the lowest with a value of (1.81g). This suggests that AM-PM can compete favourably with NPK and can conveniently replace NPK in increase yield of okra, this agrees with the report of Olawuyi et al (2011) on cucumber.

Mean performance of the nine agronomic characteristics under five different accessions.

Table 5 shows the mean performance of five okra accessions in nine agronomic characteristics. The result showed that plant height at flowering ranged between 55.60cm to 30.92cm, NH.Cb/07/008 and Bab okr3 were the highest with the values 55.60cm and 53.68cm respectively. Bab okr2 and NH.Gb/07/017 were next with 38.48cm and 37.60cm and Bab okr4 (30.92cm) was the lowest. Similarly accession NH.Cb/07/008 (60.36cm) had the highest value for plant height at maturity but was not significantly different from Bab okr3 (59.98cm) and the lowest was Bab okr4 (35.55cm) this suggests that Bab okr3 would be a good parental line in breeding for yield in okra, since height is significantly related to yield in okra (Nwangburuka et al 2011). However, stem width at maturity was highest at Bab okr2 (0.78cm) but was not significantly different from NH.Gb/07/017 (0.77cm) and the other accessions were lowest with a value of (0.70cm). leaf area at flowering ranged between 187.30cm and 76.76cm, the highest value was NH.Cb/07/008 (218.84cm) and the lowest was Bab okr4 (92.45cm). For fruit length at maturity NH.Gb/07/017 (6.72cm) had the highest value, but was not significantly different from accessions NH.Cb/07/008 (6.46cm), Bab okr2 (6.44cm) and Bab okr3 (6.23cm) and the lowest was Bab okr4 (4.95cm). fruit width at maturity ranged from 2.44cm to 1.89cm the highest fruit width recorded was in Bab okr2 (2.44cm) but was not significantly different from values obtained from NH.Gb/07/017(2.38cm) and NH.Cb/07/008 (2.37) but the lowest fruit width at maturity recorded was in Bab okr4 (1.89cm). However pod weight per plant had the highest value at Bab okr2 (8.23g), next to it was NH.Cb/07/008 (7.67g) and Bab okr3 (7.40g). All these were not significantly different from each other. This suggests that Bab okr3 and NH.Cb/07/008 would make good putative parents for selection in a hybridization program for okra fruit yield. However, Bab okr4, was the poorest in all the traits considered and may not be a good recommendation to farmers for okra fruit yield.

Correlation coefficient between nine agronomic characters of *A. esculentus*.

Table 5 shows the correlation coefficient between nine agronomic characters of *A. esculentus*. Plant height at flowering had a strong significant positive correlation with plant height at maturity, leaf area at flowering, leaf area at maturity, and fruit length at maturity. This agrees with the report of Nwangburuka et al, (2012). However,

Plant height at maturity had a strong significant positive relationship with all the characters except for stem width at maturity which was not significant at all. Meanwhile, Stem width at maturity shows a strong significant positive correlation with all the characters. *This implies that selection based on stem width will favour leaf area, which enhance rate of photosynthesis, fruit length and fruit and seed yield in okra. This agrees with the finding of Nwangburuka et al (2012). Similarly leaf area at flowering also shows a strong significant positive correlation with all the characters. Leaf area at maturity also had a strong significant positive correlation with all the agronomic characters. The same thing was applicable to fruit length at maturity, fruit width at maturity, and pod weight per plant, they all had strong significant positive correlation with all the characters except plant height at flowering. This suggests that any selection Plant height at flowering may not favour fruit width at maturity and pod weight per plant.

Table 5: Mean performance of five accessions of *A. esculentus* for nine agronomic characters.

Accession	Plant height at flowering	Plant height at maturity	Stem width at maturity	Leaf area at flowering	Leaf area at maturity	Fruit length at maturity	Fruit width at maturity	Pod weight per plant	Seed weight per plant
NH.CB/07/008	55.60a	60.36b	0.70b	187.30a	218.84a	6.46a	2.37a	7.67ab	3.79a
Bab okr2	38.48b	44.11b	0.78a	164.95b	189.81b	6.44a	2.44a	8.23a	4.11a
NH.GB/07/017	37.60b	43.23b	0.77a	136.74c	165.28b	6.72a	2.38a	6.67b	3.45a
Bab okr3	53.68a	59.98a	0.70b	143.85bc	166.21b	6.23a	2.17ab	7.40ab	3.59a
Bab okr4	30.92c	35.55c	0.70b	76.76d	92.45c	4.95b	1.89b	4.86c	2.19b

TABLE 6: Correlation coefficient between nine agronomic characters of *A. esculentus*

	Plant height at flowering	Plant height at maturity	Stem width at maturity	Leaf area at flowering	Leaf area at maturity	Fruit length at maturity	Fruit width at maturity	Pod weight per planting	Seed weight per planting
Plant height at flowering	–	0.9217*	0.0693 ^{ns}	0.3805*	0.3944**	0.3615**	0.2651 ^{ns}	0.2725 ^{ns}	0.2731 ^{ns}
Plant height at maturity	–	–	0.1429 ^{ns}	0.4468*	0.4583**	0.4279**	0.3207*	0.3834**	0.4018**
Stem width at maturity	–	–	–	0.3956*	0.4176**	0.5175**	0.4825**	0.5488**	0.4872**
Leaf area at flowering	–	–	–	–	0.9650**	0.5108**	0.3806**	0.6173**	0.6203**
Leaf area at maturity	–	–	–	–	–	0.5263**	0.3615**	0.6222**	0.6406**
Fruit length at maturity	–	–	–	–	–	–	0.7370**	0.5409**	0.5416**
Fruit width at maturity	–	–	–	–	–	–	–	0.4751**	0.4403**
Pod weight per planting	–	–	–	–	–	–	–	–	0.9243**
Seed weight per planting	–	–	–	–	–	–	–	–	1.0000

Conclusion

The treatments, Poultry Manure (PM), *Arbuscular mycorrhizae* fungi (AM), inorganic fertilizer (NPK), and combination of *Arbuscular mycorrhizae* and Poultry manure (AM-PM) exhibited significant effects in the character traits expressed by the accession considered. The five accessions also exhibited significant variability.

The high comparative significant mean performance of AM-PM treatment on all the yield related characters implies that AM-PM treatment was better than AM and PM single application and could conveniently replace NPK fertilizer in okra production as soil amendment, and will help ameliorate the negative effect of inorganic fertilizer on soil and crop.

Bab okr3, and NH.Cb/07/008 will be suitable for recommendation as good parental lines for hybridization for increase in okra yield.

Selection based on plant height, leaf area and fruit width at maturity will produce a significant increase in okra yield.

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