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EFFECTS OF NPK FERTILIZER ON THE VISCOSITY AND REPRODUCTIVE PERFORMANCE OF OKRA (*ABELMOSCHUS ESCULANTUS* (L) (MOENCH) IN A DEGRADED ISOHYPERTHEMIC ARENIC KANDIUDULT

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ABSTRACT: Investigations were conducted for two consecutive years (2005 and 2006) to study the effects of NPK fertilizer on fruit set, number of flowers formed, number of flowers aborted, weed abundance and viscosity in three cultivars of okra (*Abelmoschus esculenlus* (L) Monech). Four levels of NPK (0, 100, 200 and 300kg/ha), were applied to field grown plants in two equal doses, (2 and 6 weeks after planting) carried out at the Teaching/Research Farm and Laboratory of Federal University of Technology, Owerri, Imo State, Nigeria. All characters increased significantly with increasing levels of NPK fertilizer application. Coefficient of viscosity for the three okra cultivars as influenced by four levels of NPK application showed that the increase in the different levels of NPK fertilizer application increased the amount of the mucilage in okra which is directly related to the viscosity of the fruit. Higher levels of NPK fertilization 300kg/ha, 200kg/ha, and 100kg/ha increased the coefficient of viscosity by 492.55, 435.02, and 374.36 respectively, while the highest coefficient of viscosity was recorded by the cultivars for 2005 experiment at 300kg/ha at NPK application with NHAe47-4 having highest (593.03), V35 352.67 and Lady's finger 265.40. This superiority was maintained at different levels of NPK application for 2006 when the experiment was repeated. The effect of different levels of NPK fertilizer on weed abundance in the three okra morphotypes showed a significant difference ($p>0.05$) existing between the treatment and control for the two year experiment. highest weed scores and weight were obtained from 0kg NPK (control) plots during the 2005 experiment, with fresh weight 11-15kg $1m^2$ while fertilizer treated plots (NPK, 100, 200 and 300kg/ha^{-1}) affected weed cover-fresh weight 0-0.25kg/ha^2 and dry matter weight 0-0.24kgha^{-1}. This trend was followed in 2006 experiment. The findings from this work were explained in the light of the findings of other researcher.

KEY WORDS: NPK Fertilizers, Viscosity, Reproductive Performance, Mucilage. Albemoschus esculentus.

INTRODUCTION

Okra (*Abelmoschus esculentus* (L) (Moench) is an indigenous crop of Africa cultivated widely in west and central Africa for its immature fruits used as vegetable (Irvine, 1979). It belongs to the Malvaceae family probably believed to have originated in tropical Africa (Moody 1965). In Nigeria, as well as other poor tropical nations, vegetables will for a long time to come remain the primary and cheapest source of proteins, mineral and vitamins particularly for the low-income group. It is therefore important to seriously encourage the production and consumption of vegetables.

Okra is a very nutritious vegetable crop. Okra seeds contain approximately 21% protein, 14% lipids and 5% ash (Savello *et al.,* 1980). Okra contains very high amounts of proteins 42.71% which is frequently available at sub-optimal levels in foods of people of the developing world like Nigeria (Abanzukwe, 1989). This situation warrants more frequent inclusion of this vegetable in diets. *Irviingia gabonensis* is normally used as an alternative to okra but it contains saturated fatty acids as such its use as a daily condiments should be limited to reduce the chance of blood circulatory problems (Abanzukwe, 1989).

There is therefore real threat in terms of availability of agricultural produce. However many farmers have adopted the use of fertilizer to conserve soil fertility. Thus some farmers have used certain levels of nitrogen fertilizers to improve yields of okra. Zuofa *et al,* (1989) increased okra pod yield with 30, 60 and 90kg/ha N. Even though, fertilizer useage improved okra yield, local farmers in Nigeria believe that many disadvantages are tied with fertilizer usage Some of these disadvantages might include increased weediness, rate of pod rot and reduce viscosity "draw" of the fruit, an undesirable quality by consumers. The major problem now is the determination of the suitable rates of application to the crop which would retain the desired quality of the crop. This risk and the erroneous belief that the "viscosity" of fertilized okra is low, and has made local farmers avoid the use of fertilizer available to them at whatever rate. This could be attributed to beliefs rather than scientific proof that fertilizer reduces okra quality that is "viscosity" and storability of okra.

This research work aims at assessing the effect of different rate of fertilizer on the viscosity of okra and analyzing the effects of different rate of fertilizer on weed abundance in okra field.

MATERIALS AND METHODS

The experiment was carried out at Teaching and Research Farm of Federal University of Technology, Owerri situated on latitudes 5° 27' and longitudes 78° 2'E in 2005 and 2006 respectively. The area has minimum and maximum temperatures of 20°C and 32°C with a mean annual rainfall of about 2500mm per annum (Nwosu and

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Adeniyi, 1980). Soils of the area has been classified as isohyperthermic Arenic Kandiudult (Nwosu, and Adeniyi 1980), characterized by high acidity, low cation exchange capacity, low base saturation and low fertility status, usually buffering from multiple nutrient deficiencies. Farmers either resort to bush fallow or use of inorganic fertilizer to boost soil nutrient.

The experiment was carried out in 2005 and 2006 cropping seasons using Randomized Complete Block Design with three replications. The treatments include four levels of fertilizer zero kg/ha, 100kg/ha, 200kg/ha and 300kg/ha of N.P.K and three okra cultivar NHAe 47-4, characterized as early flowering with thick fresh pods, the cultivar was obtained from NIHORT, Ibadan, Nigeria. Lady finger It was obtained from ADP, Owerri and V35, this has the same characteristics as NHAe 47-4. It is an exotic cultivar, also from ADP, Owerri.

The field was under fallow for one year after maize to which NPK compound fertilizer 15;15:15 was previously applied. The pre-cropping vegetation in the experimental sites was mainly annual and broad leaved weeds.

The site was cleared and prior to seedbed preparation, soil samples were randomly collected from the experimental site using soil anger to a depth of 15cm. the samples were taken to the laboratory and analysed for pre-cropping soil physical and chemical characteristics (Table 1). The soil samples were air dried and passed through 2mm sieve. Particle size was determined by hydrometer method (Hulugake *etal.*, 1991). Total precocity was calculated from values of bulk density obtained by clod method (Blake and Hartage, 1986), assumed particle density of 2.65g/cm3. Exchangeable basic cations were estimated by complexometric titration and flame photometry method (Jackson, 1958). Exchangeable acidity was measured by the procedure of Mclean (1965). Cation exchange capacity (CEC) was determined by the neutral ammonium acetate method as described by Chapman (1965). Percent base and aluminum saturations were calculated as follows

$$\text{Base saturation} = \frac{\text{Total exchangeable basic cations}}{\text{C.E.C}} \times \frac{100}{1}$$

$$\text{Aluminum saturation} = \frac{\text{Exchangeable aluminum}}{\text{CEC}} \times \frac{100}{1}$$

Total carbon was measured by Walkely and Balck wet digestion method (Robles and Fabro, 1979), while organic matter was obtained by multiplying total carbon by a factor of 1.724. Total Nitrogen was determined using micro Kjeldahi (Bremner, and Mulvane, 1982) while available phosphorus was estimated using Bray 11 method (Bray and Kurtz, 1954). The soil reaction was measured according to the procedure of Handerson *et al,* (1993). The effective cation exchange capacity (ECEC) was determined by summation of exchangeable cation and acidity (IITA, 1979).

Planting was done on a seed beds measuring 9.5 x 1m. Each seedbed represented an experimental plot and there were 36 plots. The seeds were sown 3 per hole and spaced 30 x 30 cm apart. Each block was respectively applied with 0, 100, 200 and 300kg/ha of N.P.K 15:15;15 fertilizer using band method in 2 equal doses. The first dose was applied two weeks after planting (WAP) and the second dose was six weeks after planting. Okra varieties was treated with *Peperomia pellucida* powder as recommended by Ibe, *et al* (1998).

Determination of Viscosity

Freshly harvested okra was collected from different cultivars and treated Freshly harvested okra was sorted to remove old fibrous or woody pods. Pods of about 7cm 10cm in length were selected because at this stage of maturity they are of good eating quality. They were trimmed, washed, drained and sliced. Okra pods of 4kg of the homogenate was put into a measuring cylinder containing 25ml of that distilled water and allowed to stay for 15minutes before analyzing with Rheometre (Baroid Hoston Texas) viscometer but because stokes formula can be used to measure the coefficients of viscosity of very viscous liquids such as okra. Viscosity of the fruits was assessed by the method described by Nelkon and Parker (1979) using the stock formular

$$\text{VISCOSITY} = \frac{2ga^2(e - Q)}{g\,Vo}$$

Where coefficient of viscosity

a	=	radius of p (ball)
Q	=	density of liquid
e	=	density of bearing material
Vo	=	terminal velocity
g	=	acceleration due to gravity

Fruits were homogenized in a blender and 4g of the homogenate was put into a measuring cylinder containing 25ml of distilled water and stirred. A ball of 3mm radius was thrown into the graduated measuring cylinder and with the help of a clock, the time taken for the ball to get to the bottom of the cylinder was determined. The density of the liquid and the bearing materials was estimated by Archimedes principle.

The co-efficient of viscosity was latter calculated using the stocks formular.

Weed abundance was measured by the method described by Kershaw (1973). Weed density was measured by a 1m x 1m guardant thrown at random and the weed species within the guardant counted and identified using drawings manuals and keys described by Hutchinson (1973). Weed weight was estimated by weighing the weeds on a balance until a constant weight was obtained. The number of flowers formed per plant at flowering was counted and recorded. Number of flowers aborted was estimated by taking a second count of flowers formed after 7days interval and subtracted from the initial count. Also the number of okra fruit per plant was counted and recorded.

RESULTS AND DISCUSSION

The pre-planting soil physical and chemical properties before the experiment are shown in Table 1. The soil pH value 4.5 in water indicates high acidity with low concentrations of organic carbon 1.87 and total nitrogen contents (0.22%). Also the exchangeable carbons such as magnesium, calcium, potassium and sodium are low in concentration.

Table 1: Pre-planting soil physical and Chemical Reactions

Soil property	Mean
Total sand (%)	82
Silt (%)	3
Clay (%)	15
Textual class	5L
Total porosity (%)	40
Exchangeable ca (cmolkg-^{1})	1.70
Exchangeable Mg (cmolkg-^{1})	0.50
Exchangeable K (cmolkg-^{1})	0.10
Exchangeable Na (cmolkg-^{1})	0.01
Exchangeable H (cmolkg-^{1})	1.20
Exchangeable Al (cmolkg-^{1})	2.80
Effective cation	
Exchange capacity (cmolkg-^{1})	5.40
Base saturation (%)	42.27
Aluminum saturation	53.52
Total carbon (%)	1.87
Total Nitrogen (%)	0.22
Available phosphorus (mg/kg)	9.13
Soil pH in water	4.82
Soil pH in Kcl	3.86

SL = Sandy Loam

Rainfall was high from May to October in 2005 and the same in the 2006. The soil temperature was high all through the year, although it was lower during the period of high rainfall (Table 1). The air temperatures at this time are relatively higher than at other times. Water deficit has a great impact on plant development and it varies with the stage of growth. Inadequate moisture supply limits nutrient uptake and metabolic activities leading to reduced crop growth and yield (Duncan, 1971).

The effects of NPK fertilizer on the reproductive performance of the three okra cultivars are presented in Table 3. All characters measured were significant for the two years except the number of flowers aborted per plant. NPK application increased both the number of flowers formed per plant and the number of flowers aborted per plant significantly, indicating that as more flowers were produced, only a proportionate number developed into fruits. Also the number of flowers formed per plant was increased by 32 73% following NPK application, while flowers aborted increased by 53-59%. Despite the increase in flower abortion, NPK fertilizer increased fruit sets up to 4-15% compared to the control (0kg NPK/ha) plots. There were significant difference (p=0.05) in the response of the three cultivars to the same level of NPK fertilization (Table 3). V35 cultivar had the best performance with high mean values for all characters. Although this superiority was maintained at different levels of NPK application. The highest degree of response was exhibited by NHAe47-4 followed by Lady's finger. Number of fruit set per plant, flowers formed and flower aborted were the most sensitive parameters to NPK application as indicated by the large degree at positive responses. This view is borne out by the fact that the 3 cultivars differed in degrees of positive response associated with NPK fertilization. However, farmers especially in the developing countries like Nigeria are facing difficulties with increasing costs of fertilizers. Breeding efforts are therefore, directed at the development of cultivars which produce well under a low level of fertility and respond well to added nutrients. In this regard, cultivars such as NHAe 47-4 or Lady's finger may be considered. Boil applied nitrogen fertilization influences the concentrations of NPK and Mg in okra fruit and leaves but this partly is a function of variety and growth stage. Plant analysis is a useful aid in determining fertilizer requirements of okra.

The results on co-efficient of viscosity for the three okra cultivars as influenced by different levels of NPK application indicates a major significant (p=0.05) differences existing between the treatment levels and the control. The reason could be due to the increase in the different levels of NPK fertilizer application which increased the amount of the mucilage (that is concentration of an okra system) which is directly related to the viscosity of the system (Table 4). Higher levels of NPK fertilization (300kg NPK/ha, 200kg NPK/ha and 100kg NPK/ha) in 2006 increased the co-efficient of viscosity by 729.00, 615.30 and 575.72 respectively. In 2005, the highest co-efficient of viscosity was recorded by the cultivars, NHAe 47-4 (729.21), V_{35} (577.86), and Lady's finger (325.73) in the descending order respectively. This superiority was maintained in 2006. This finding agrees with Ejiofor, (1985) who reported that viscosity could serve as an index of the amount of mucilage present on okra system and the higher the amount of mucilage the more viscous the solution will be. This means that increase in the concentration of aqueous system at viscous substance resulted in an increase in the viscosity value. The mucilaginous product at the blended okra is a visco-elastic substance which was observed by Olorunda and Tung, (1977) in their work on archeology of fresh frozen okra.

CONCLUSION

The investigations into the effects of NPK 15:15:15 fertilizer on viscosity and reproductive performances of okra in a degraded isohyperthemic Arenic kandiudult soil at Southeastern, Nigeria implicated their NPK fertilizer requirements. The cultivars which produced well under level of NPK 15:15:15 fertilizer are the most desirable. The result also shows that NPK treatments gave the crops early take-off to produce more leaves that enabled them to suppress obnoxious annual and perennial weeds.

The influence of NPK 15:15:15 levels on three okra cultivars on viscosity of the fruit indicated that high levels of NPK application increased the viscosity of the fruits.

Table 2: Climatic Data for Owerri Imo State, Nigeria, 2005/2006

Months	Temperatures				Rainfall (mm)		Relative Humidity	
	2005		2006					
	MAX	MIN	MAX	MIN	2005	2006	2005	2006
January	34.2	23.8	33.8	20.1	31.7	14.6	58.5	58.5
February	36.5	23.0	36.4	24.90	0.0	0.0	53.0	56.0
March	34.0	24.6	35.5	11.9	21.51	48.7	57.0	58.5
April	32.7	24.0	35.0	25.1	309.8	130.5	75.0	75.0
May	32.3	23.5	33.5	24.7	542.7	253.7	74.5	77.0
June	30.7	23.4	32.2	23.8	504.8	289.4	80.0	78.5
July	29.7	23.0	30.4	23.5	311.9	290.3	77.0	98.5
August	29.2	23.2	30.9	23.1	323.0	168.5	79.5	79.0
September	31.0	23.5	30.8	23.7	245.2	179.2	76.5	79.0
October	31.9	23.3	31.3	23.7	245.2	179.2	76.5	79.0
November	32.2	23.6	33.3	24.4	137.4	12.4	76.0	77.0
December	33.6	24.0	33.3	23.1	28.7	0.0	63.0	61.0
Total	387.9	282.9	397.5	271.7	2889.9	1641.5	848.5	856.0
Mean	32.3	23.6	33.1	22.6	240.8	136.8	70.7	71.3

Source: Federal Ministry of Aviation, Meteorological Unit, Owerri, Imo State. Nigeria.

Table 3: Reproductive Performances of Three okra cultivars as Influenced by NPK 15:15:15 Application in 2005 and 2006

(kg/ha^{-1})	Cultivar	No of flowers formed/plant	No of flowers aborted/plant	No of fruits set/plant
	NHAe 47-4	9.47	4.02	5.10
	Lady's finger	9.18	5.07	4.08
Control	V35	10.52	5.16	5.17
	Mean	7.71	4.73	4.77
	LSD (0.05)	0.81	0.71	0.69
	NHAe 47-4	15.34	8.76	6.35
	Lady's finger	11.80	6.77	5.04
100	V35	11.34	6.11	4.91
	Mean	16.64	7.20	5.42
	LSD (0.05)	6.25	1.53	0.91
	NHAe 47-4	16.07	8.94	6.66
	Lady's finger	12.59	7.40	5.11
200	V35	12.81	6.11	6.04
	Mean	13.83	7.47	5.94
	LSD (0.05)	2.17	1.59	0.86
	NHAe 47-4	11.89	9.02	5.19
	Lady's finger	13.56	6.97	5.10
300	V35	12.74	6.47	4.46
	Mean	12.70	7.49	4.90
	LSD (0.05)	0.90	1.54	0.44
	NHAe 47-4	12.61	7.68	5.81
	Lady's finger	11.36	6.54	4.84
Cultivars mean	V35	11.88	5.98	5.16
	LSD (0.05)	1.35	0.99	0.58
Year	2005	12.06	6.74	4.60
	2006	12.51	6.74	5.95
	LSD (0.05)	0.37	NS	1.07

ble 4: Effect of NPK 15:15:15 Fertilizer Levels on the Co-efficient of Viscosity in the three okra cultivars

NPK level (kgha^{-1})	Cultivar	2005	2006
	V_{35}	268.90	272.71
Control	NHAe47-4	456.25	448.72
	Lady's finger	209.49	207.50
	V_{35}	316.72	314.42
100			
	NHAe47-4	577.86	575.72
	Lady's finger	228.50	227.65
	V_{35}	398.34	399.42
200			
	NHAe47-4	608.81	615.30
	Lady's finger	297.90	299.50
	V_{35}	422.70	421.86
300			
	NHAe47-4	729.21	729.00
	Lady's finger	325.73	324.92
	Total	4840.38	4836.72
	Mean	403.37	403.06
	S.D	163.19	128.39

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