INFLUENCE OF WEED INTERFERENCE DURATION ON THE YIELD AND VISCOSITY OF OKRA (*Abelmoschus esculentus* (L) *Moench*) VARIETIES IN SOUTH-EASTERN NIGERIA

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ABSTRACT

Field studies were carried out at the Teaching and Research Farm of the Federal University of Technology, Owerri, Nigeria to determine the influence of weed interference on the yield and viscosity of three okra (*Abelmoschus esculentus* (L.) Moench) varieties. Three varieties of okra (NHAe47-4, Lady's finger and V_{35}) were weeded using five weeding regimes (weedy check, unweeded till 5 weeks after sowing (WAS), weeding once each at 3 WAS and 4 WAS and weed free). The treatment combinations were laid out in a randomized complete block design with three replications. NHAe47-4 was shorter than the other varieties but produced larger leaves and more flowers than the rest in both years. Higher fruit yields (23.63t ha^{-1} in 2007 and 22.96t ha^{-1} in 2008) were produced by NHAe47-4 among the weeded plots which were not significantly different from the weed free plots (24.20 and 22.13t ha^{-1} in 2007 and 2008, respectively). Better weed control was achieved from NHAe47-4 (80.65 and 76.97% in 2007 and 2008, respectively) comparable with the weed free plots. The viscosity of okra from the weeded plots is in the decreasing order of NHAe47-4 < V35 < Lady's finger in 2007 and 2008. The result showed that among the weeded plots okra variety NHAe47-4 weeded at 3 WAS was more viscous than the others and will therefore be of greater acceptability to the food consumers.

Keywords: okra varieties, weed interference, viscosity, weed control efficiency, south - eastern Nigeria, fruit yield.

INTRODUCTION

Okra (*Abelmoschus elsculentus* L. Moench) is one of the most important vegetables grown in Nigeria including some tropical and subtropical countries. Other major okra growing countries are India, Pakistan, Ghana and Egypt. In Nigeria it is grown predominately by peasant farmers' usually in home gardens or in mixture with other cereal crops (Lombin *et al*., 1985). It is grown for its young leaves and green pods. The immature leaves and fruits are very rich sources of vitamins and minerals and are eaten in various forms. The nutritional composition of okra includes calcium, protein, oil and carbohydrates, iron, magnesium and phosphorus (Omotosho and Shittu, 2007). Okra seeds contain approximately 21% protein, 14% lipids and 5% ash (Savello *et al*., 1980). Most of the okra is eaten in cooked or processed form and the young fruits may be eaten raw. Akinfasoye and Nwanguma (2005) noted that the oil in the seed could be as high as in poultry eggs and soybean. It also contains a fair proportion of carbohydrates which are present as cellulose, starch, in small quantity and sugar (Fellows, 2000). It also contains non-cellulose, non-starch, polysarcharides (Fellows, 2000). It is a source of vitamins C and A, iron and calcium (Ihekoronye and Ngodd, 1985) and dietary fibre (Adom *et al*., 1996). Okra is grown in West Africa primarily, because of its slimy drawing characteristics which constitutes it selling quality and which give okra soup its viscous quality relished in swallowing 'garri' or '*fufu*' by Nigerians. As mostly used in the fresh state, the Western part of Nigeria use it commonly as a soup thickener, cooking of yam, etc. The okra pod which is quite slimy even after cooking is most often used in stews, soups and gravis, giving a thickening effect in soups (Janick *et al*., 1981). Okra's viscosity is attributed to the water soluble poysaccharides molecules found in its cell walls (Sarah, 2011). This characteristic can be enhanced or reduced by different methods of preparation. In Israel, those who don't like the slimy nature fry okra in olive oil while others prefer boiling it in lemon juice or citric acid (Sarah, 2011). The slimy property of okra fruit is of great importance to its acceptability and food value to consumers (Uzo and Ojiako, 1980). The more slimy or viscous okra is better and is rated as food thickener. Okra mucilage is suitable for industrial and medicinal applications. It is used as a plasma replacement or blood volume expander. The mucilage of okra not only binds cholesterol but the bile acid carrying toxins dumped into it by the filtering liver. Industrially, okra mucilage is usually used to glace certain papers and also useful in confectionery among other uses (Markose and Peter, 1990; Shalau, 2002; Siemonsmo and Kouame, 2004). In Nigeria, the limiting factors in okra production among others include weed management, tillage practices, low yielding varieties and sub-optimal planting density (Adejonwo *et al*., 1989; Burnside, 1993; Dikwahal *et al*., 2006, Adeyemi *et al*., 2008). According to Kalssen and Schwartz (1985), approximately 600 species of insects, 1, 800 species of plants, and numerous species of fungi and nematodes are considered serious pests in agriculture. They further stated that if these pests were not managed, crop yields and quality would drop likely increasing production costs and food and fibre prices. Producers with greater pest problems would become less competitive. This implies that the much desired useful quality of the okra mucilage will be lowered by weed competition during growth. The presence of weeds can

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also reduce the quality of forages or make them unpalatable or even poisonous to livestock (Akobundu, 1987; Anon., 2013). Many weeds taint milk, for example, wild garlic and canada thistle leaves and nightshade berries can contaminate processed vegetable (Anon, 2013). The viscosity of okra can be lowered by post harvest storage techniques and drying methods. Adetuyi *et al*. (2008) recorded the least percentage loss in moisture, fibre, antioxidant and viscosity with storage method of 100% RH at temperature of 10^0C $\pm$ 2^0C than storage in polypropylene bag. The work of Eze and Akubor (2012) showed that blanched and over-dried okra (Lady's finger) samples packaged in air-tight container and stored in dark, cool place, retained more of its chemical composition and viscosity than the blanched and sun-dried, packaged and stored in dark cool place.

This study therefore, was carried out to determine the effects of weed interference duration on the yield and viscosity of okra varieties.

MATERIALS AND METHODS

Two field experiments in May 2007 and 2008 were conducted at the Federal University of Technology Teaching and Research Farm, Owerri, Nigeria situated between latitudes 5^0 20'N and 5^0 27'N and between Longitudes 7^0E and $7^0$07'E. The area has a bimodal rainfall with annual mean rainfall of 240 and 137mm in 2007 and 2008, respectively. There are two seasons: the wet season from April to October and dry season from November to March with a characteristic of cold dry dust laden wind interval (harmattan) during the months of January to February.

Soil sample was collected before planting, oven dried, ground and sieved through 2mm sieve and the sand, silt and clay contents were determined by the Bouyoucos method (1951). The soil pH was determined using the pH-metre in a 1:2.5 soil/water ratio, total Nitrogen content was by micro-kjedahl method (Jackson, 1962) total phosphorus was by Bray 1 method (Bray and Kurtz, 1945). Calcium (Ca) and Magnesium (Mg) were determined by the Atomic Absorption Spectrophotometer (AAS) and potassium (K) and sodium (Na) by flame emission photometry. The organic carbon was according to Walkey and Black (1934) and the present organic matter was estimated by multiplying the percent organic carbon with a factor of 1.724. The soil has the following characteristics; pH (in H_20) 5.0, organic carbon 1.29%, total N 0.24%; extractable P 4.94mg kg^{-1}, extractable K 0.11, Ca 1.62 and Mg 0.59 in cmol Kg^{-1}. Soil particle distributions were sand 47%, clay 31% and silt 22%. The soil was classified as sandy ultisol (Ibe, 2005). The soils have low mineral reserves and are therefore of low fertility. Climatic data was obtained from the University Meteorological Unit. The land was ploughed and harrowed with the aid of tractor mounted implements in both years. The okra seeds (variety NHAe47-4) used for the experiment were obtained from the National Horticultural Research Institute (NIHORT) at Mbato, Okigwe, Nigeria.

The seeds were treated with *Pereomie pellucid*a leaf powder at 30g per 100 seeds as recommended by Ibe *et al*. (1988). Three seeds per hole were planted on the flat with a spacing of 0.6m x 0.3m between and within the rows respectively and later thinned to one plant per stand. Commercial formulation of NPK fertilizer was applied at the rate of 0, 100, 200, and 300 $kgha^{-1}$. There were five weeding regimes: weedy check, regular weeding up to 5 weeks after sowing (WAS), weeding once at 3 WAS, weeding once at 4 WAS and weed free. Treatments were arranged in split-plot design with NPK fertilizer rates as main plot factor and weeding regime as sub-plot factor with three replications giving a total of 60 plots. Fertilizer was applied at 2 WAS. Chemical spraying with cypermetricin was carried out to check the incidence of insect pests that affect the leaves of okra plant.

Growth and yield parameters determined were plant height, leaf area, number of flowers produced and aborted, fresh fruit yields, coefficient of viscosity, weed density, weed dry weight and weed control efficiency. The viscosity of okra mucilage was measured using the Ostwald viscometer as described by AOAC (1990). Weed density was measured by a 1 x 1m quadrat thrown at random and the weed species indentified within the quadrat and counted. Weed control efficiency was calculated based on the method suggested by Bhattacharya and Mandal (1988) as follows:

$$\frac{\text{Dry Weed Weight (DWT) of unchecked control-DWT of Treatment}}{\text{DWT of unweeded Control}} \times 100$$

The data collected were subjected to analysis of variance (ANOVA) and means compared using the Duncan Multiple Range Test (DMRT) at a probability of 5% according to Gomez and Gomez (1984).

RESULT AND DISCUSSIONS

Growth parameters

The results of the growth parameters for both years are presented in Table-1 which showed that the growth parameters were significantly affected by the crop variety and the weeding regimes. Lady's finger grew taller than the other two varieties in the two years under study. This pattern was reported by Iyagba *et al*., (2012). NHAe47-4 significantly produced larger leaves, more flowers than Lady's finger and V_{35} in both years. While some workers have observed significant difference in growth parameters of okra varieties, other researchers did not observe significant difference (Adejonwo *et al*., 1989; Majanbu *et al*., 1988). This has been attributed to the fact that okra varieties are sensitive to environmental changes (Katung, 2007; Ijoyah *et al*., 2009).

Duration of weed interference significantly affected okra growth parameters. Least growth parameters were observed from the unweeded okra plots. Plots weeded at 4 WAS or kept weed free till 5 WAS did not indicate any significant difference from the weeded plots in plant height and leaf size. In both years plant height, leaf size and the quantity of flowers formed were not significantly different. Keeping the plots unweeded beyond 3 WAS in both years resulted into higher flower

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abortion which can cause lower fruit formation. This shows that okra plants can tolerate weed up to 3 WAS without adverse effect. This is in line with the findings of Adejonwo *et al*., (1989). It has also been recorded that most crops have certain level of tolerance to weed competition and length of period they are required to be weed free (Scott *et al*., 1979; Ayeni and Oyekan 1992, and Dada and Fayinminnu, 2007).

Fruit yield

Table-2 presents fresh fruit yield as well as the viscosity of okra plant varieties. The result showed significant (P = 5%) response among the okra varieties. Greater fresh fruit yield/plant was recorded from the NHAe47-4 and Lady's finger. NHAe47-4 and V_{35} produced higher fruit yield/hectare though not statistically different than Lady's finger in both years. This could be attributed to the larger leaves produced by these two cultivars which had enabled them to manufacture greater assimilates during their photosynthetic activities. The yields obtained from NHAe47-4 were 23.63 and 22.96t ha^{-1} in 2007 and 2008 and for V_{35}, 22.94 and 22.34t ha^{-1} in 2007 and 2008, respectively. On the whole, crop yield in 2007 was better than that of 2008 which was as a result of the poor rainfall in 2008. The crop variety has significant effect on okra viscosity (Table-2). NHAe47-4 variety was significantly more viscous than the other two varieties, but no significance difference was noticed between Lady's finger and V_{35} in 2007 and 2008. This shows varietal difference in the viscosity of the crop. Weed interference duration also significantly influenced the degree of okra's viscosity. The plots that were weed free were more viscous while the least viscosity was obtained from the unweeded plots. The viscosity of the weed free plots was statistically different in 2007 (1658 cp) and 2008 (1651 cp) from the plots that were infested with weeds for 3 WAS (1430 and 1420 cp in 2007 and 2008 respectively). The viscosity of okra plots with weed interference duration of 4 WAS and 5 WAS were statistically similar.

Weed control

The prominent weed types at the experimental plots in 2007 and 2008 were more from the families of Asteraceae, Cyperaceae, Euphorbiaceae, Poaceae and less from Urtricaceae and Verbenaceae (Table-3).

The performance of the okra varieties were affected by the weed dry weight, weed density, and weed control efficiency (Table-4). Weed control from NHAe47-4 was higher than the other varieties (80.63 and 70.97% in 2007 and 2008, respectively). The resultant effect of this would be less competition for growth resources like nutrient and water.

Keeping the plots weed free and weeding at 3 WAS did not result into any significant difference in weed control efficiency in 2007 and 2008. This might explain the insignificant difference in yield obtained in the fruit yield/hectare between the weed free plots and those weeded at 3 WAS. Also noticed was the non significant difference in weed density from the unweeded plots and keeping the plot weed free till 5 WAS. This might suggest that allowing the plots weed free till 5 WAS gave rise to the accumulation of growth resources to enable the weeds grow vigorously after this period. The low viscosity of okra plants from this treatment could be attributed to this. The lowest okra yields and viscosity were observed in the weed infested plots till harvest in each of the varieties while the highest yields and greater viscosity were obtained from the weed free plots. Also observed was lowering of the crop yield and viscosity with longer weed interference duration. This is due to reduced competition for resources like nutrients, water and light. The composition of mucilage is attributed to the water soluble polysaccharides molecules found in its cell walls (Sarah, 2011) while Owoeye *et al*. (1990) noted that okra contains large quantities of glycans, which are responsible for the viscosity of the aqueous suspension. Increase in weed interference duration will lead to reduction in soil moisture available for absorption and therefore less amount of water in the okra fruits. The work of Adetuyi *et al*., (2008) showed that increase in storage days of okra (lowering of moisture) led to a reduction in viscosity while the work of Eze and Akubor (2012) revealed that higher storage temperature decreased the moisture content of okra and consequently its viscosity. It therefore implies that longer weed interference duration which will result into less amount of moisture available for absorption by the okra plants and will lead to lower viscosity. The reduction in viscosity could be attributed to the utilization of carbohydrate during metabolic processes at the reduced moisture level because mucilage is a polysaccharide which is carbohydrate (Adetuyi *et al*., 2008). Decrease in moisture level due to increase in weed interference duration could lead to decrease in protein. This may be attributed to the physiological and metabolic activities within the cells of the okra pod and at the same time due to proteolysis which is the breakdown of protein. Potter and Hotchkiss (1996) also reported that the rhelogical properties of starch and gums in food may be altered by heat (less moisture) and the hydrophilic properties of such foods may be altered. There is therefore a reduction in the viscosity of okra when weeds are not controlled. Such will lead to a reduction of the market value of the crop for users as soup thickener.

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Table-1. Effect of okra varieties and weed interference duration on growth parameters in 2007 and 2008.

Treatment	Plant height (cm)		Leaf area plant (cm^2)		No. of flowers formed/plant		No. of flowers aborted/plant	
	2007	2008	2007	2008	2007	2008	2007	2008
Okra cultivars								
NHAe 47-4	71.2b[2]	70.0b	38.2a	36.7c	12.8a	13.7a	2.4a	2.4a
Lady's finger	86.7a	86.3a	33.4b	32.2b	10.6b	11.6b	1.9ab	1.8b
V_{35}	68.9b	68.6b	36.1a	36.1a	12.6a	13.4a	2.2a	2.2a
Mean	75.6	74.97	35.9	35.0	12.0	12.9	2.17	2.13
SE($\pm$)	9.7	8.03	2.4	1.99	0.9	1.11	0.20	0.25
Weed interference duration								
Weedy check	33.8c	33.6bc	18.2b	17.9b	5.8c	6.7c	3.1a	3.0a
Weed infested for 3 WAS	61.0b	60.40	34.6a	33.8a	10.4a	11.3a	2.3b	2.2b
Weed infested for 4 WAS	37.1bc	36.7b	29.9b	28.4ab	8.5b	8.9b	3.2a	3.1a
Weed free until 5 WAS	46.9b	46.2b	22.1b	20.7b	6.9b	7.2b	3.3a	3.2a
Weed free until harvest	69.2a	48.8a	38.2a	36.2a	12.6a	13.4a	2.4b	2.0b
Mean	49.6	49.4	28.6	27.4	8.84	9.5	2.9	2.7
SE ($\pm$)	15.2	13.55	8.4	9.79	2.44	2.8	0.3	0.50

[1]Weeks after sowing [2]values followed by the same letter(s) in a column are not significantly different at 5% level using DMRT

Table-2. Effect of okra varieties and weed interference duration on yield parameters and viscosity of okra in 2007 and 2008.

Treatment	Fresh fruit wt./plant		Fruit yield (tha^{-1})		Viscosity (cp)	
	2007	2008	2007	2008	2007	2008
Okra cultivars						
NHAe 47-4	26.46a	28.62a	22.96a	23.63a	1691a	1680a
Lady's finger	22.81a	23.92a	19.38b	20.48b	1616b	1608b
V_{35}	18.63b	19.46b	22.34a	22.94a	1630b	1626b
Mean	22.63	24.00	21.56	22.35	1645.6	1638.0
SE($\pm$)	3.22	4.6	1.56	1.7	19.6	21.6
Weed interference duration						
Weedy check	1.05d	1.08d	6.72a	6.24c	649d	643d
Weed infested for 3 WAS	17.26b	18.06b	20.43a	22.16a	1430b	1420b
Weed infested for 4 WAS	14.07b	4.79b	13.73b	13.98b	1001c	995c
Weed free until 5 WAS	3.29c	3.80c	9.54c	10.24c	969c	963c
Weed free until harvest	19.33a	21.21a	22.12a	24.20a	1658a	1651a
Mean	11.00	11.79	14.41	15.46	1141.4	1134.4
SE ($\pm$)	7.44	8.98	6.11	7.53	179.2	178.7

[1]Weeks after sowing [2]values followed by the same letter(s) in a column are not significantly different at 5% level using DMRT

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Table-3. Cumulative weed flora composition at the experimental site in 2007 and 2008.

Weed types	Plant family	Growth form	Degree of occurrence
Amaranthus spinosus	Amaranthaceae	ABL	XX
Celosia loxa	Amaranthaceae	ABL	XX
Ageratum conyzoides	Asteraceae	ABL	XX
Aspilia africana	Asteraceae	PBL	XX
Chromoleana odorata	Asteraceae	PBL	XXX
Tridax procumbens	Asteraceae	ABL	XX
Commelina benghalensis	Commelinaceae	PSB	XX
Conmelina diffusa	Commelinaceae	PSB	XX
Cyperus rotundus	Cyperaceae	PS	XXX
Cyperus tuberosus	Cyperaceae	PS	XX
Euphorbia heterophyila	Euphorbiaceae	ABL	XXX
Phyllantus amarus	Euphorbiaceae	ABL	XX
Mimosa pudica	Leguminosae	PBL	X
Sida acuta	Malvaceae	PBL	X
Boerhavia diffusa	Nyctaginaceae	PBL	XX
Axonopus compressus	Poaceae	PG	XXX
Cynodon dactylon	Poaceae	PG	X
Eleusine indica	Poaceae	AG	XX
Eragrostis atrovirens	Poaceae	PG	XX
Paspalum conjugatum	Poaceae	PG	XX
Panicum maximum	Poaceae	PG	X
Sporobalus pyramadalis	Poaceae	PG	XX
Talinum triangulare	Portulacaceae	PBL	XX
Diodia scandiens	Rubiaceae	PBL	X
Mitracarpus villosus	Rubiaceae	ABL	XX
Physalis angulata	Solanaceae	ABL	X
Laportea aestuans	Urticaceae	ABL	XX
Starchytopheta cayenensis	Verbenanceae	PBL	XX

ABL= Annual Broad Leaf, PBL = Perennial Broadleaf, PSP = Perennial Spiderwort, PG = Perennial Grass, PG = Perennial Grass, PS = Perennial Sedges, AG= Annual Grass
X = Low weed occurrence, XX = Medium weed occurrence, XXX = High weed occurrence

Table-4. Effect of okra varieties and weed interference duration on weed dry weight, weed density and weed control efficiency in 2007 and 2008.

Treatments	Weed dry weight ($kgha^{-1}$)		Weed density (no/m^2)		Weed control efficiency (%)	
	2007	**2008**	**2007**	**2008**	**2007**	**2008**
Okra-cultivars						
NHAe47-4	91b	111b	20c	23b	80.63a	76.97a
Lady's finger	163a	180a	26a	26a	65.32b	62.66b
V_{35}	154ab	166b	23b	24a	67.32b	65.56b
Mean	136	152.33	23	24.33	71.06	68.40
SE($\pm$)	25.32	19.92	2.45	2.16	3.3	2.5
Weed interference duration						
Weedy check	530a	582a	33a	33a	-	-
Weed infested for 3WAS[1]	518b	526b	14b	15b	75.13a	74.47a
Weed infested for 4 WAS	524b	540b	17b	18b	51.41bc	50.98bc
Weed free until 5 WAS	556a	577a	26a	28a	24.40c	23.83c
Weed free until harvest	0c	0c	0c	0c	100a	100a
Mean	293.60	359.00	18	18.80	62.74	62.32
SE ($\pm$)	38.31	38.10	11.22	11.44	28.02	28.18

[1]Weeks after sowing [2]Values followed by the same letter(s) in a column are not significantly different at 5% level using DMRT

CONCLUSIONS

This work has shown that NHAe47-4 is more viscous than Lady's finger and V35 which are commonly cultivated in this region and that viscosity of okra varieties will reduce with weeding carried out beyond 3 WAS.

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