RESPONSE OF SOME SESAME VARIETIES TO WEED MANAGEMENT PRACTICES IN A MOIST SAVANNA AREA OF NIGERIA

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ABSTRACT

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Field study was conducted during the 2014 and 2015 growing seasons at Minna in southern Guinea savanna of Nigeria to assess the agronomic performance of five sesame varieties (NCRIBEN 01M, 02, 03, 04, and 05) under four weed management practices: (i) weedy check, (ii) pre-emergence (PE) application of butachlor at 0.125 kg a.i.ha^{-1} followed by (fb) post emergence (POE) application of fluazifop-p-butyl at 0.038 kg a.i.ha^{-1}, (iii) PE application of butachlor fb hoe weeding (HW) at 6 weeks after sowing (WAS), and (iv) two hoe weeding at 3 + 6 WAS (2HW) using a 5 x 4 factorial combination in a randomized complete block design with three replications. Results indicated that the most dominant weed species in sesame field were Vernonia galamensis, Cynodon dactylon, Euphorbia heterophylla, Hyptis suaveolens, Spigelia anthelmia, Cyperus rotundus, Tridax procumbens, Commelina benghalensis and Ludwigia decurrens. Weed management practices reduced weed biomass, but increased sesame height, capsule length, number of capsule per plant, seeds per capsule and seed yield. The 2HW reduced weed biomass the most, produced taller plants, longer capsules, and increased seed yield by 41.4 % in 2014 and 75.6 % in 2015 relative to the weedy check. These results were comparable to those under PE application of butachlor fb HW at 6 WAS. In both years, variety, interaction between weed management and variety were not significant on weed control, growth, and yield of sesame. These results suggest that 2HW, and PE application of butachlor fb HW at 6 WAS could sustain weed control in sesame production in savanna agro ecology in Nigeria.

Keywords: *Growth; sesame; varieties; weed management practice; yield*

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an important and probably the oldest oilseed crop known to man (Azeez and Morakinyo, 2011). It is largely cultivated for food, feed, and oil in several countries in the tropics and subtropical regions of Africa, Asia, South and North America, and some parts of Russia (Haruna, 2011). In Nigeria, the major growing areas of sesame are in the northern part which lies within the savanna region (Imoloame *et al.*, 2010). The production of this crop is below expectation compared to other oilseed crops, though it has considerable potential to produce higher yield (Pham *et al.*, 2010; Azeez and Morakinyo, 2011). In order to reverse this, the Federal Government launched a national programme on this crop so as to stimulate its production in Nigeria by providing the best practices, principles, and skills in seed production. In addition, the Raw Materials Research and Development Council (RMRDC) and Olam Nigeria Limited also launched several programmes to boost and encourage sesame production in the major producing areas in the country (Makama *et al.*, 2011). The National Cereals Research Institute (NCRI) in Nigeria also made some significant progress by developing seeds of improved varieties to increase and encourage sesame production across the producing states in the country. Despite the efforts made towards increasing sesame production in Nigeria, the average sesame seed yield on farmers' fields lies between 90 and 250 kg ha^{-1}, lower than 350 kg ha^{-1} being the world average yield (Imoloame *et al.*, 2010) ; and lower than 1323 kg ha^{-1} and 825 kg ha^{-1} yields from Egypt and Ethiopia, respectively (Umar *et al.*, 2012).

The low productivity of sesame are partly attributed to weed infestation (Imoloame *et al.*, 2010), ignorance and reluctance by the farmers to adopt improved cultural practices, and lack of access to improved sesame seeds for use (Umar *et al.*, 2012). In Nigeria, major sesame farmers are largely smallholders, who do not have access to improved inputs such as seeds, fertilizers and other agrochemicals, and as well lack access to information on recommended agronomic practices that can improve the crop yield (Olowe and Adeoniregun, 2010; Umar *et al.*, 2012). Consequently, the low productivity and poor agronomic practices have discouraged farmers; and reduced the total area of land under sesame cultivation in Nigeria (Ngala *et al.*, 2013). In the same trend, Abdasalam and Al-Shebani (2010) noted that low sesame crop yield is largely due to cultivation on marginal lands, using low plant density, heavy weed infestation and non-availability of promising cultivar. Weed management is an important agronomic practice required for achieving higher crop productivity. In order to close the yield gap of sesame in Nigeria, a study was conducted to determine the response of some sesame varieties, with different maturation period, to some weed management practices in the southern Guinea savanna of Nigeria.

MATERIALS AND METHODS

Experimental site

Field study was conducted during the 2014 and 2015 growing seasons at Minna (9° 53.42'N, 6° 45.23'E; 210 m above sea level) in southern Guinea savanna of Nigeria. The climate of the area is sub-humid tropical, with an average annual rainfall of 1200 mm, 90% of it falling between June and August; with minimum mean daily temperature that rarely falls below 22 °C between February to March, and maximum temperatures of 36-40 °C in November-December (Adeboye *et al.*, 2011). The experimental soil in 2014 was loamy sand in texture (866 g kg^{-1} sand, 60 g kg^{-1} silt, and 74 g kg^{-1} clay) and acidic in reaction (pH 6.8) with 2.53 g kg^{-1} organic carbon, 0.02 g kg^{-1} total N, 3 mg kg^{-1} available P, 0.16 g kg^{-1} soluble K, 8 cmol kg^{-1} Ca, 2.4 cmol kg^{-1} Mg, and 0.04 cmol kg^{-1} exchangeable acidity. Soil type in 2015 was sandy loam (850 g kg^{-1} sand, 14 g kg^{-1} silt, and 136 g kg^{-1} clay) acidic in reaction (pH 5.7) with 2.25 g kg^{-1} organic carbon, 0.06 g kg^{-1} total N, 5 mg kg^{-1} available P, 0.33 g kg^{-1} soluble K, 2.1 cmol kg^{-1} Ca, 2.4 cmol kg^{-1} Mg, and 0.03 cmol kg^{-1} exchangeable acidity. During the experimental period (July – October) total rainfall were 699.2 mm and 639.7 mm in 2014 and 2015 respectively. The experimental fields had over the years been put to continuous cultivation in the rainy seasons to maize, sorghum and yam as intercrops with fertilizer application.

Treatments and experimental design

Five sesame varieties (Table 1) and four weed management practices: (i) weedy check, (ii) pre-emergence (PE) application of butachlor herbicide at 0.125 kg a.i. ha^{-1} + one hoe weeding (HW) at six weeks after sowing (WAS), (iii) PE herbicide application + post emergence (POE) herbicide application of fluazifop-p-butyl at 0.038 kg a.i. ha^{-1} at 6 WAS, and (iv) 2 HW at 3+ 6 WAS consisted the treatments. The experimental design was a 5 x 4 factorial combination in randomized complete block design with three replications. Gross plot size was 3.75 m x 4 m containing five ridges of 4 m long each; while the net plot size was 3 m x 3 m consisting of the three middle row ridges. An alley of 1 m was left between replicates and 0.5 m between treatment plots.

Cultural practices

The field was disc-ploughed with a tractor, levelled with a hand hoe, and manually ridged at 75 cm apart. Sesame seeds were dressed with Ciba/Apron Plus® (Imidacloprid 10% + metalaxyl 10% + carbendazim 10%) at the rate of 10 g per 4 kg seeds, and then sown manually at 1.5 cm depth and at 15 cm intra row spacing. Sesame seedlings were thinned to two plants per stand at 2 WAS, to achieve a plant population of 88,889 plants ha^{-1}. Weeding was conducted as per the treatment combinations. Butachlor and Fluazifop-p-butyl herbicides were sprayed with a CP15 knapsack sprayer fitted with a red deflector nozzle delivering the spray solution of 250 L ha^{-1} at a pressure of 2 kg m^{-2}. In addition, hoe weeding was carried out as per the treatment combinations. At 3 WAS, a basal application of 30 kg N, 30 kg P_2O_5 and 30 kg K_2O ha^{-1} in form of N:P:K (15-15-15) was applied at 5 cm away from the plant by dibbling. The remnant of 30 kg N in form of urea (46%) was applied in the same manner at 6 WAS.

Table 1: Agronomic characteristics of sesame varieties used in this study

Variety	Original name	Outstanding characteristics	Potential yield
NCRIBEN 01M	530-6-1	Attractive seed colour	600-700 kg ha^{-1}
NCRIBEN 02M	TYPE-4 (No.1)	Delay shattering and medium maturity	550-600 kg ha^{-1}
NCRIBEN 03L	GOZA-25	Drought tolerant, good seed quality	500-550 kg ha^{-1}
NCRIBEN 04E	Ex-Sudan	High grain yield, high oil content, and early maturity	1.3 t ha^{-1}
NCRIBEN 05E	KENANA 4	High yield, high oil content, and early maturity	1.2 t ha^{-1}

Source: Catalogue of crop varieties released and registered in Nigeria, Volume 6 (2014). E – early, M – medium, L - late

Data collection

Weed measurements were determined using a 0.5 m x 0.5 m quadrat which was randomly thrown at four points along the diagonal transects in each plot at 3, 6 and 9 WAS. Before every weeding, weeds were manually clipped at each sampling time from the soil level. The weeds were identified, counted by species, and used to determine the dominant weed species using the weed occurrence index as described by Silva *et al.* (2013). The clipped weeds were bulked, and oven dried at 80 °C to a constant weight to obtain dry weed biomass.

Sesame growth parameter measurements

Six randomly tagged plants within each net plot were used for Sesame growth parameter measurements. Height and number of leaves per plant were measured at 4, 8 and 12 WAS. Height was measured from the tagged plants, from the soil level to the tip of the topmost leaf with a metre rule and averaged. At physiological maturity, when most of the leaves had brown and shading off, with dark brown stems and yellow pods that were fully matured; all the tagged plants were used to determine the number of capsules, capsule length, and seeds per capsule. Number of capsules per plant from each plot were determined and averaged. In addition, five capsules were plucked from each plant in each plot to measure the length and averaged. The number of seeds per capsule was determined from 12 randomly selected matured capsules at harvest and then averaged. Seed yield in kg ha^{-1} was calculated from the capsules harvested from the net plot. All the plants in the three inner rows were harvested by cutting at the soil level when the capsules had turned yellow. The plants were tied in bundle to a peg, in an upright position for further sun drying. Manual threshing and winnowing were performed to obtain clean seeds.

Statistical analysis

Data obtained were subjected to analysis of variance using the General Linear Model (GLM) procedure of Statistical Analysis System (SAS) software package version 9.0. The least significant difference (LSD) test at $P \leq 0.05$ was used to compare the differences between treatment means.

RESULTS

Weed species composition

Twenty-six weed species were observed across the treatments (Table 2). The dominant weed species infesting the sesame field at 3, 6 and 9 WAS in each year was *Vernonia galamensis*

Table 2: Weed species composition and their occurrence index across four weed management practices and five sesame varieties in 2014 and 2015 seasons

		3 WAS		6 WAS		9 WAS	
Weed species	Family	2014	2015	2014	2015	2014	2015
Grass							
Cynodon dactylon (L.) Pers.	Poaceae	85.0	43.3	56.7	3.3	10.0	1.7
Digitaria horizontalis Willd	Poaceae	-	1.7	3.3	1.7	28.3	1.7
Pennisetum spp	Poaceae	-	-	3.3	-	5.0	-
Bracharia lata (Schumach) Hubbard	Poaceae	-	-	-	6.7	-	-
Paspalum scrobiculatum L.	Poaceae	-	-	-	6.7	-	-
Broad leaved							
Euphorbia heterophylla L.	Euphorbiaceae	76.7	-	41.7	46.7	11.7	46.7
Vernonia galamensis (Cass.) Less.	Asteraceae	65.0	60.0	70.0	68.3	21.7	73.3
Hyptis suaveolens (L.) Poit.	Lamiaceae	8.3	38.3	21.7	43.3	25.0	51.7
Spigelia anthelmia L.	Rubiaceae	31.7	-	56.7	10.0	36.7	11.7
Commelina benghalensis L.	Commelinaceae	6.7	-	15.0	28.3	1.7	16.7
Amaranthus spp	Amaranthaceae	-	28.3	68.3	1.7	61.7	-
Solanum nigrum L.	Solanaceae	-	25.0	-	-	-	-
Ipomoea triloba L.	Convolvulaceae	-	5.0	3.3	1.7	-	-
Gomphrena celosioides Mart.	Amaranthaceae	-	1.7	6.7	1.7	1.7	5.0
Tridax procumbens L.	Asteraceae	-	-	16.7	25.0	6.7	68.3
Ludwigia decurens Walt.	Onagraceae	-	-	13.3	23.3	43.3	6.7
Mimosa pigra L.	Fabaceae	-	-	8.3	-	1.7	-
Calopogonium mucunoides L.	Fabaceae	-	-	6.7	-	-	-
Boerhavia diffusa L.	Nyctaginaceae	-	-	-	1.7	-	-
Oldenlandia corymbosa L.	Rubiaceae	-	-	-	1.7	-	-
Ageratum conyzoides L.	Asteraceae	-	-	-	3.3	-	-
Physalis angulata L.	Solanaceae	-	-	-	-	1.7	-
Scoparia dulcis L.	Scrophulariaceae	-	-	-	1.7	-	-
Sedge							
Cyperus rotundus L.	Cyperaceae	1.7	30.0	75.0	30.0	66.7	18.3
Kyllinga erecta Schumach.	Cyperaceae	-	1.7	-	8.3	-	10.0
Kyllinga pumila Michx.	Cyperaceae	-	-	1.7	-	21.7	-

(Cass.) Less. *Cynodon dactylon* (L.) Pers., *Euphorbia heterophylla* L., *Hyptis suaveolens* (L.) Poit., *Spigelia anthelmia* L., *Commelina benghalensis* L., *Amaranthus* spp., *Tridax procumbens* L., *Ludwigia decurrens* Walt., and *Cyperus rotundus* L. were also of high infestation at various sampling times. All the other weed species observed were scanty.

Weed biomass

Weed management practices had significant (P<0.05) effect on weed biomass at each sampling period in 2014 and 2015 (Table 3). When compared with the weedy check and 2HW, at 3 WAS in each year, PE + 1 HW, and PE + POE recorded similar lowest weed biomass (Table 4). Similarly at 6 WAS, 2 HW, in each year consistently recorded the lowest weed biomass than the other weed management practices. However at 9 WAS in 2014, the lowest weed biomass was recorded in plots given PE + 1 HW which was in turn comparable to 2 HW. In 2015, the lowest weed biomass was observed in plots given 2 HW while PE + 1HW and PE + POE were higher.

Plant height

Weed management practices had a significant effect (p<0.05) on sesame height in 2015 only (Table 5). Taller plants were observed in the weedy check plot at 4 WAS, though similar to those in plots given 2 HW (Table 6). The herbicide treatments in the other hand had were similar. Furthermore, at 8 WAS, plots given PE + 1 HW, 2 HW recorded similar taller plants than plots with PE + POE. At 12 WAS, the weedy check, PE + 1 HW and 2 HW recorded similar, but significantly taller plants than that given PE + POE.

Capsule length

Capsule length differed significantly between weed management practices in 2014 only (Table 7). Weedy plots had the shortest capsules, than the weed control treatments, which were similar Table 8).

Table 3: ANOVA and mean squares of weed biomass in sesame in a moist savanna location in Nigeria in 2014 and 2015 rainy seasons

		Weed biomass (g m^{-2})		
Source of variation	DF	3 WAS	6 WAS	9 WAS
2014				
Replication	2	39.201	3132.620	85.886
Weed management (W)	3	57.416**	8768.774*	8513.206**
Variety (V)	4	2.084NS	289.831NS	1255.627NS
W × V	12	1.903NS	653.783NS	769.98NS
Error	38	3.980	1187.781	916.924
2015				
Replication	2	11.961	414.295	1356.366
Weed management (W)	3	19.205**	7960.997**	6459.056**
Variety (V)	4	0.713NS	89.732NS	93.237NS
W × V	12	0.394NS	295.972NS	65.381NS
Error	38	0.637	292.739	137.058

NS: not significant; * significant at 5% level of probability; ** significant at 1% level of probability; WAS – weeks after sowing

Table 4: Effect of weed management practice on weed biomass (g m^{-2}) in sesame in a moist savanna location in Nigeria in 2014 and 2015 seasons.

	3 WAS		6 WAS		9 WAS	
Weed management practices	2014	2015	2014	2015	2014	2015
Weedy check	4.67	3.29	92.05	91.17	74.76	69.13
PE + 1HW	1.27	1.15	64.95	59.03	21.80	33.95
PE + POE	0.87	0.85	60.15	56.46	54.11	30.71
2HW at 3 + 6 WAS	4.19	2.40	33.02	35.34	30.98	22.05
LSD (0.05)	1.5	0.6	25.5	12.6	22.4	8.7

WAS – weeks after sowing; PE – pre-emergence herbicide; POE- post emergence herbicide; HW – hoe weeding

Table 5: ANOVA and mean squares of plant height of sesame in a moist savanna location in Nigeria in 2014 and 2015 rainy seasons

		Plant height (cm)		
Source of variation	DF	4 WAS	8 WAS	12 WAS
2014				
Replication	2	108.033	2212.700	2216.351
Weed management (W)	3	0.506NS	226.028NS	177.761NS
Variety (V)	4	2.730NS	48.327NS	13.650NS
W × V	12	127.966NS	82.175NS	64.168NS
Error	38	5.487	214.503	133.520
2015				
Replication	2	2.707	1304.967	1658.875
Weed management (W)	3	42.367*	367.519*	324.063*
Variety (V)	4	24.261NS	10.608NS	17.630NS
W × V	12	13.419NS	33.794NS	50.452NS
Error	38	12.143	78.349	82.990

NS: not significant; * significant at 5% level of probability; ** significant at 1% level of probability; WAS – weeks after sowing

Table 6: Effect of weed management practices on sesame plant height (cm) in a moist savanna in Nigeria in 2015 season

Weed management practices	4 WAS	8 WAS	12 WAS
Weedy check	17.9	57.7	77.9
PE + 1HW	14.7	61.8	79.8
PE + POE	14	52.4	70.9
2 HW at 3 + 6 WAS	15.6	63.6	81.5
LSD$_{(0.05)}$	2.6	6.5	6.7

WAS – weeks after sowing; PE – pre-emergence herbicide; POE- post emergence herbicide; HW – hoe weeding

Table 7: ANOVA and mean squares of capsule length, number of capsules per plant, number of seeds per capsule and seed yield of sesame in a moist savanna location in Nigeria in 2014 and 2015 rainy seasons

Source of variation	DF	Capsule length (cm)	Number of capsules (per plant)	Number of seeds (per capsule)	Seed yield (kg ha^{-1})
2014					
Replication	2	0.777	2823.217	26.871	368725.593
Weed management (W)	3	0.399**	1976.861*	96.728NS	201123.461*
Variety (V)	4	0.022NS	93.183NS	22.833NS	8834.842NS
W × V	12	0.018NS	52.927NS	18.367NS	10728.276NS
Error	38	0.028	268.673	63.764	56070.309
2015					
Replication	2	0.046	104.617	72.917	294125.96
Weed management (W)	3	0.156NS	766.722**	92.467*	1840673.29**
Variety (V)	4	0.015NS	10.900NS	4.858NS	77125.55NS
W × V	12	0.040NS	32.189NS	9.925NS	117804.52NS
Error	38	0.059	47.178	28.583	79431.33

NS: not significant; * significant at 5% level of probability; ** significant at 1% level of probability

Table 8: Effect of weed management practices on some sesame yield and yield attributes in a moist savanna in Nigeria

	Capsule length (cm)	Number of capsules per plant		Number of seeds per capsule	Seed yield (kg ha^{-1})	
	2014	2014	2015	2015	2014	2015
Weedy check	2.6	39	38	23	345.16	421.7
PE + 1HW	2.8	61	51	28	579.71	772.3
PE + POE	2.9	59	48	25	453.46	334.2
2 HW at 3 + 6 WAS	2.9	64	55	28	589.38	1098.9
LSD (0.05)	0.1	12.1	5.1	3.9	175.0	208.3

WAS – weeks after sowing; PE – pre-emergence herbicide; POE- post emergence herbicide; HW – hoe weeding

Number of capsules

The effect of weed management was significant ($p<0.05$) on number of capsules per plant in 2014 and 2015 (Table 7). The weed control treatments produced similar number of capsules that were greater than that in weedy check in 2014 (Table 8). However, in 2015 weed control treatment plots had more capsules than the weedy check. Similar highest number of capsules was found in the PE + 1 HW and 2 HW plots, and significant differences were also found within the treatments containing 2 HW and PE + POE.

Seeds per capsule

Seeds per capsule of sesame differed significantly between weed management practices in 2015 only (Table 7). The weed control plots had similar but higher number of seeds per capsule than weedy check plot (Table 8).

Seed yield

Weed management practices significantly ($P<0.05$) affected sesame seed yield, but not variety, and their interaction in 2014 and 2015 (Table 7). In 2014, sesame seed yield was comparable in plots given PE + 1 HW and 2 HW treatments, but higher than the PE + POE and the weedy check plot (Table 8), representing 40.6 and 41.4 % increase, respectively compared with the weedy check. In 2015, 2 HW had the highest sesame seed yield compared to other weed management practices, except PE + 1 HW. This increase represented 69.6, 29.7 and 61.6 % compared with PE + POE, PE + 1 HW and weedy check, respectively.

DISCUSSION

The consistent presence of *V. galamensis* (Cass.) Less as the most dominant weed species infesting sesame was a demonstration of its morphological plasticity. This phenomenon enables it to cope with the existing conditions of the farmland. In an earlier study, Tang *et al.* (2014) reported that under contrasting ecological and soil fertility conditions, different weed species can exhibit morphological plasticity, because of their ability to form some adaptive mechanisms. Furthermore, the variation in the composition of other dominant and scanty weed species infesting the sesame was the result of variation in rainfall and subsequent dry conditions of the farmland. This finding is in line with Mahajan *et al.* (2014) who noted that alternating wet and dry conditions could influence weed species diversity, depending on the weed competitive ability of the crop varieties used. The pre-emergence application of butachlor fb supplementary hoe weeding and sequential application of butachlor fb post emergence application of fluazifop-p-butyl, sufficiently and effectively reduced weed biomass in the early growing period of sesame crop. These suggest that the application of PE herbicide alone suppressed weed seed germination and emergence in crop early growth stage. In addition, hoe weeding or post emergence herbicide application, effectively controlled the weeds that emerged during the mid - late period of crop growth. The results of our study support earlier findings by Ghatak *et al.* (2006) that pre-emergence herbicide application or in combination with hoe-weeding can effectively control weed infestation as also provided by two hoe weeding.

Furthermore, as the growing season progressed from mid to late season, 2HW consistently reduced the weed biomass better. Our study clearly demonstrated and confirmed earlier findings by Imoloame *et al.* (2010) that hand weeding alone can effectively and successfully control weed infestation in sesame production. Plots treated with PE butachlor fb 1 HW, and 2HW, consistently produce taller sesame plants, because of effective weed control which minimized weed competition for growth resources, which translated into healthy crop growth and development. Two-hoe weeding was consistent in producing longer capsules, more capsules per plant, greater seeds per capsule and highest seed yield of sesame. Similarly, application of butachlor fb 1 HW though not consistent in both years also followed a similar trend with two hoe weeding. The positive effect of two-hoe weeding and application of butachlor fb 1 HW treatments in increasing yield attributes and yield of sesame was due to reduction in competition of weeds with the crop. This finding is similar to results in previous studies in sesame, in which improved yield and yield attributes were obtained in plots either hand weeded alone or with PE application of herbicide + hand weeding (Ghatak *et al.*, 2006).

Furthermore, the improved production of longer capsules and more capsules per plant under sequential application of butachlor fb fluazifop-p-butyl demonstrated its ability to serve as an alternative to hoe weeding in sesame production. These results are similar to the findings of Tuti and Das (2011) who found that pre-fb- post emergence application of metribuzin resulted in the production of greater number of pods per plants, though in soybeans.

CONCLUSION

On the basis of findings from this study, it could be concluded that two hoe weeding at 3 + 6 WAS, and pre-emergence application of butachlor at 0.125 kg a.i. ha^{-1} fb hoe-weeding at 6 WAS reduced weed growth and maximized seed yield of sesame.

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