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SEED RATE AND NITROGEN FERTILIZER EFFECTS ON WEED BIOMASS, GROWTH AND YIELD OF TWO SESAME (*SESAMUM INDICUM* L.) VARIETIES

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Abstract

Field experiments were conducted in the wet seasons of 2009 to 2011, at the Research Farm of the Institute for Agricultural Research, Ahmadu Bello University, Samaru (11° 11′ N, 07° 38′ E), in the northern Guinea savanna zone of Nigeria, to evaluate the influence of seed rate and nitrogen fertilizer on weed biomass, growth and yield of two sesame (*Sesamum indicum* L.) varieties. The treatments consisted of factorial combination of four seed rates (2, 4, 6 and 8 kg ha^{-1}), four application rates of inorganic nitrogen (0, 30, 60 and 90 kg N ha^{-1}) and two sesame varieties (NCRIBEN 01M and E8). The treatments were laid in a randomized complete block in a split plot arrangement with three replications. Seed and nitrogen rates were assigned to the main plot; while crop variety was assigned to the sub plot. Variety E8 in general reduced weed biomass, than NCRIBEN 01M. Conversely variety E8 produced the highest seed yield (6.5 %) compared to NCRIBEN 01M. Seed rates of 2 kg ha^{-1} gave lower weed biomass while 8 kg ha^{-1} produced taller plants, more number of capsules and highest seed yield. Seed yield increased with increase in seed rate such that it was 68.8 %, 60.1 % and [illegible] % for 8, 6 and 4 kg ha^{-1} over the 2 kg seed ha^{-1}, respectively. Nitrogen rates had no significant effect on weed biomass produced. However, application of 90 kg N ha^{-1} produced taller plants, more capsules per plant and highest seed yield. Seed yield increased with increase in application of nitrogen such that it was 48.4 %, 42.1 % and 22.4 % for 90, 60 and 30 kg N ha^{-1} over 0 kg N ha^{-1}, respectively. From this study it was observed that the use of 8 kg seed ha^{-1} together with the application of 90 kg N ha^{-1} and E8 was promising for weed growth reduction and maximum seed yield and may be recommended for higher production of sesame in the northern Guinea savanna of Nigeria.

Key words: Nitrogen, sesame, seed rate, variety, weed biomass

Introduction

Weeds are one major factors limiting sesame (*Sesamum indicum* L.) production as well as in other crops in the tropics in general (Ijlal *et al*., 2011; Take-tsaba *et al*., 2011). The crop is a poor competitor with weeds because of its slow seedling growth especially at its early stage of growth (Ijlal *et al*., 2011). Under a poorly established plants, weed competition reduced sesame yields by 68 % (Take-tsaba *et al.*, 2011).

In this regard, weed control has remained one of the major production problems faced by sesame farmers in Nigeria. For example, in the major sesame producing agro-ecologies of Nigeria; the farmers recognize that low yield potential in association with the problems of attaining effective weed control, as well as the losses of seeds encountered at harvest have led to a reduction in the area put to sesame cultivation (Take-tsaba *et al.*, 2011). Though herbicide use has revolutionized farmers approach to weed control, the public is very much concerned about its effect on the environment and human health (Olsen *et al.*, 2006). This has therefore increased the interest of developing alternative methods for effective weed control in the production of this crop. In addition, the method should be that which is capable of producing crops in an economically viable and ecologically sustainable manner.

However, information in literature on the use of crop variety for weed management in sesame production is scanty. However, the fact remains that adoption of crop cultivar can reduce weed growth as numerous experiments have shown that while seed rate has a strong and negative influence on weed biomass production, it has a positive effect on crop biomass and yield (Shinggu *et al.*, 2009). It is also noted that application of nitrogen fertilizer could increase weed emergence and growth, by stimulating the germination of dormant weed seeds from the soil seed bank (Zewdie *et al.*, 2004). In the same vein, fertilizing an oilseed crop like sesame with nitrogen under rainfed or irrigated conditions are beneficial to crop growth and development (Purushottam, 2005). In order to encourage sesame growers for sustainable yield, it was ideal to study weed control management which will include variety, seed rate and nitrogen fertilizer in a sustainable manner.

Hence the objective of this study was to determine the effect of seed rate and nitrogen application rates on weed growth, growth and yield of two sesame varieties in a northern Guinea savanna of Nigeria.

Materials and methods

Field experiments were conducted during the 2009, 2010 and 2011 rainy seasons at the Research farm of the Institute for Agricultural Research, Ahmadu Bello University, Samaru (Lat. 11° 11'N, Long. 7° 38'E, 686 m above sea level) in the northern Guinea savannah ecological zone of Nigeria. The area has distinct rainy and dry seasons (Sambo *et al.*, 20[illegible]; Ewansiha *et al.*, 2014). Rainfall establishes between mid-may to early June, and is concentrated between July and August, while the dry season starts from mid-October to end of April (Sambo *et al.*, 2013). The experimental site was previously cropped to maize in 20[illegible], castor in 2010 and groundnut in 20[illegible] respectively. Detailed analysis of the physical and chemical properties of soil sample (0 – 30 cm) and weather data taken from the experimental sites are shown in Tables 1 and 2.

The experiment was established as a factorial combination of four seed rates (2, 4, 6 and 8 kg ha^{-1}), four levels of nitrogen (0, 30, 60 and 90 kg N ha^{-1}) and two sesame varieties (NCRIBEN 01M and E8) in a randomized complete block with a split plot arrangement and replicated three times. Seed and nitrogen rates were assigned to the main plot and variety was assigned to the sub plot. Gross plot size was 3.6 m x 4 m (14.4 m^2) consisting of six rows, and net plot size was 1.2 m x 4 m (4.8 m^2) consisting of two rows. Each row was spaced at 60 cm apart. In each year, the experimental area was ploughed and harrowed twice with a tractor to a fine tilt. These was then levelled and marked out into flat seed beds plots with hoes. Basal dose of 15 kg ha^{-1} P_2O_5 and 15 kg ha^{-1} K_2O was done and incorporated into the soil during land preparation in each year. N was applied as per the treatment. Half of N was applied at sowing by side placement, 5 cm away from the seed row and 5 cm deep, and according to treatment. The remaining half of N was applied at 4 WAS by drilling with hand, 5 cm away from seed row (United States Agency for International Development, 2008). Urea (46 % N), single super phosphate (18 % P_2O_5) and muriate of potash (60 % K_2O) were the fertilizers used as sources of N, P and K respectively. Sowing was manually done on a flat seed bed. The seeds were mixed with fine sand in 1: 4 proportions before drilling. Sesame seeds were sown by drilling in shallow trenches made at 60 cm spacing inter- row according to seed rate on 3 August, 2009; 29 July, 2010 and 26 July, 2011, by hand. No thinning was carried out. Manual weeding of the plots was carried out at 3 and 6 WAS using hand hoes. Incidence of insect pest, especially sesame leaf roller (*Antigastra catalaunalis* L.) was controlled by the application of cypermethrin (CyperForce 10 % EC) at 0.10 kg a.i.ha^{-1} weekly between 6 WAS and 8 WAS.

All the plants in each net plot were manually harvested at full physiological maturity on 16^{th}, 11^{th} and 8^{th} November, 2009, 2010 and 2011, respectively; when the colour of the leaves had changed from green to yellow and started to fall off and the capsules turned yellow and fully ripe. The plants were cut at the base close to the soil with the aid of a sickle. These were then tied in an upright position and adequately dried under the sun before threshing.

Weed samples were collected from two 0.5 m × 0.5 m quadrats placed along a diagonal in each plot at 3, 6 and 9 WAS. All the weed species in each quadrat were clipped at the ground level at each sampling period, then bulked and oven dried at 70^0C to constant weight to determine the weed biomass, and then converted to grams per m^2. Five plants were randomly selected and tagged from each net plot to determine sesame height per plant at 12 WAS and number of capsules per plant taken at maturity. Seed yield was recorded from the entire plants harvested within the net plot, after manual threshing and winnowing and thereafter weighed and expressed in kg ha^{-1}.

The data collected were subjected to analysis of variance (ANOVA) using the Statistical Analysis System (SAS version 9.0). Differences between the treatment means were separated using the Least Significant Difference (LSD) at 5% level of probability.

Results

Table 1 show that the soil (0-30 cm depth) in 2009, 2010 and 2011 were sandy loam respectively; low in organic carbon and total nitrogen except in 2011 which was high.

The result of rainfall amount and distribution is shown in Table 2. The total amount of rainfall received during the experimental period of July through

November 2009, 2010 and 2011 were 1083.1 mm, 823.7 mm and 631.6 mm, respectively. Total rainfall was higher in 2009 compared to 2010 and 2011 seasons. The highest mean rainfall was recorded in the month of August, 2009, 2010 and 2011 by 439.7 mm, 313.4 mm and 239.9 mm, respectively.

The weed biomass among plots grown to two sesame varieties at 6 and 9 WAS in 2009, 3 WAS in 2010, 3 and 6 WAS in 2011and 9 WAS in the combined mean differed significantly ($P \leq 0.05$) (Table 3). Plots grown to E8 variety significantly ($P \leq 0.05$) reduced weed biomass produced compared to NCRIBEN 01M variety at 6 and 9 WAS in 2009 and 9 WAS in the combined mean; while the opposite occurred at 3 WAS in 2010; 3 and 6 WAS in 2011, respectively. Similarly seed rate significantly ($P \leq 0.05$) influenced weed biomass produced at 3, 6 and 9 WAS in 2009; 3 and 6 WAS in 2010; 6 WAS in 2011 and 3, 6 and 9 WAS in the combined mean, respectively. The use of 2 kg seed ha^{-1} produced less weed biomass that were similar with 4 kg seed ha^{-1} at 9 WAS in 2009, 4 and 6 kg seeds ha^{-1} at 3 WAS in 2010; 4 kg seed ha^{-1} at 6 WAS in 2011 and 4 kg seed ha^{-1} in the combined mean. In contrast application of nitrogen had significant ($P \leq 0.05$) effect on weed biomass produced at 6 WAS only in 2011 trial, such that the use of 60 kg N ha^{-1} depressed weed biomass produced when compared to the untreated control. The other treatments were at par with both the lowest and highest N rates.

The interaction of seed and nitrogen rates on weed biomass in sesame at 3 WAS in 2009 and 2010 were significant ($P \leq 0.05$) (Table 4).Weed biomass was significantly ($P \leq 0.05$) lowest at 2 kg seed ha^{-1} with application of 90 kg N ha^{-1}, which did not significantly ($P \leq 0.05$) differ from 2 kg seed ha^{-1} with [illegible] kg N ha^{-1}, 4 kg seed ha^{-1} with 30 kg N ha^{-1}, [illegible] kg seed ha^{-1} with 0 or 30 kg N ha^{-1} and 8 kg seed ha^{-1} with 0 kg N ha^{-1} plots. In 2010, the least weed biomass was observed in combination 6 kg seed ha^{-1} with application of 0 kg N ha^{-1} which was at par with 2 kg seed ha^{-1} in combination with [illegible] 30 and 60 kg N ha^{-1}; and 4 kg seed ha^{-1} with application of 0 and 30 kg N ha^{-1}. The highest weed biomass was recorded in combination 8 kg seed ha^{-1} with application of 0 and 30 kg N ha^{-1}.

The effect of seed and nitrogen rates on plant height of two sesame varieties at 12 WAS in 2009, 2010, 2011 and combined mean are presented in Table 5. Sesame variety E8 resulted in significantly ($P \leq 0.05$) taller plants than NCRIBEN 01M in 2010 only. Plant height differed significantly ($P \leq 0.05$) due to seed rate in 2010, 2011 and the combined mean such that it increased as seed rate was increased from 2–8 kg ha^{-1}. The tallest plants were recorded at the 8 kg seeds ha^{-1} than the lower rates. Similarly plant height also responded significantly ($P \leq 0.05$) to nitrogen rates in the manner that application of N at 90 kg ha^{-1} produced taller plants than the lower rates and the control in 2010 and the combined mean only.

The number of capsules per plant differed significantly ($P \leq 0.05$) between the two sesame varieties in 2011 only, such that NCRIBEN 01M produced more capsules than E8 in the year of study (Table 6). Number of capsules per plant also differed significantly ($P \leq 0.05$) due to seed rate in 2009, 2010 and 2011 and the combined mean. In 2009, seed rate at 4 kg ha^{-1} and beyond produced significantly ($P \leq 0.05$) more number of capsules than 2 kg ha^{-1}. However in 2010, 2011 and the combined data, seed rate at 8 kg ha^{-1} produced more capsules than the other seed rates. In general, the use of 2 kg ha^{-1} had the fewest number of capsules in each year. Application of nitrogen significantly ($P \leq 0.05$) influenced the number of capsules per plant produced in each year and the combined. Application of 30 kg N ha^{-1} in 2009; 90 kg N ha^{-1} in 2010, 2011 and combined resulted in more capsules. In contrast 0 kg N ha^{-1} produced the fewest number of capsules per plant in each year.

The interaction between seed rates and variety on number of capsules per sesame plant in 2010 and 2011 were significant ($P \leq 0.05$) (Table 7). It was observed that 8 kg seed ha^{-1} observed more number of capsules per plant when NCRIBEN 01M variety was used in both years of study. But lowest number of capsules per plant was observed with the seed rate of 2 kg ha^{-1} in both varieties in each year, which did not significantly ($P \leq 0.05$) differ from 4 and 6 kg seed ha^{-1} in both varieties in 2010 only.

In the same vein, the interaction between seed and nitrogen rates in 2009, 2010, 2011 and combined data on number of capsules were significant ($P \leq 0.05$) (Table 8). The result revealed that combination of 8 kg seed ha^{-1} and 30 kg N ha^{-1} in 2009, 8 kg seed ha^{-1} and 90 kg N ha^{-1} in 2010, 2011 and combined data produced the highest number of capsules per plant, while seed rate of 2 kg ha^{-1} plus 0 kg N ha^{-1} produced the least number of capsules per plant in each year of the study.

Data in Table 9 showed that the two sesame varieties did not vary significantly ($P \leq 0.05$) in their seed yield in 2009; whereas in 2010, 2011 and the combined, the response was significant ($P \leq 0.05$), though not consistent. Variety E8 produced 22.9 % and 6.5 % more seed yield than NCRIBEN 01M in 2010 and combined means respectively, while the reverse was the case in 2011 when NCRIBEN 01M produced 13.4 % more seed yield than E8. The response of sesame seed yield to seed rate was significant ($P \leq 0.05$) in the three years of study and the combined. The use of 8 kg seed ha^{-1} increased seed yield by 89.2 %, 54.7 %, 66.5 % and 68.8 % in 2009, 2010, and 2011 and in the combined respectively over the least produced by 2 kg seeds ha^{-1}. Application of nitrogen significantly ($P \leq 0.05$) influenced sesame seed yield in each of the year and the combined. In 2009, plots that received 60 kg N ha^{-1} produced the highest seed yield that was similar to 90 kg N ha^{-1}. However in 2010, 2011 and combined data, plots that received 90 kg N ha^{-1} produced the highest seed yield. These yields were significantly ($P \leq 0.05$) higher than those obtained from the other plots. In general application of 90 kg N ha^{-1} increased seed yield by 38.4 %, 65.4 %, 39.2 % and 48.4 % over the least by the control in 2009, 2010, 2011 and the combined, respectively.

The interaction between seed and nitrogen rates on seed yield of sesame in 2010, 2011 and combined was significant ($P \leq 0.05$) (Table 10). The combination of 8 kg seed ha^{-1} and 90 kg N ha^{-1} had significantly ($P \leq 0.05$) higher seed yield ha^{-1}, while seed rate of 2 kg ha^{-1} plus 0 kg N ha^{-1} produced the least seed yield of sesame ha^{-1}, which did not differ with seed rate of 2 kg ha^{-1} plus 30 kg N ha^{-1} in the combined mean only.

The interaction among variety, seed and nitrogen rate had remarkable effect on seed yield ha^{-1}, in 2010 and 2011 (Table 11). The result showed that variety

E8 sown at 8 kg seed rate ha^{-1} and given 90 kg N ha^{-1} produced the highest seed yield ha^{-1} in 2010. Both varieties sown at 8 kg seed rate ha^{-1} and given 90 kg N ha^{-1} produced the highest seed yield ha^{-1} in 2011. The least seed yield was recorded in both varieties when sown at 2 kg seed rate ha^{-1} and supplied with 0 kg N ha^{-1} in 2010, and with variety E8 sown at 2 kg seed ha^{-1} without N in 2011.

Table 1. Physical and chemical properties of soils taken from 0 – 30 cm depth at the experimental site before establishment of the trial at Samaru

	Soil depth (0 – 30 cm)		
Soil characteristics	2009	2010	2011
Particle size			
Sand (g kg^{-1})	600	600	560
Silt (g kg^{-1})	280	260	280
Clay (g kg^{-1})	120	140	160
Textural class	Sandy loam	Sandy loam	Sandy loam
Chemical composition			
pH in water	5.50	5.70	5.90
pH in 0.01 M $CaCl_2$	4.80	4.50	4.80
Organic carbon (g kg^{-1})	3.9	3.9	3.3
Total nitrogen (g kg^{-1})	0.021	0.026	0.25
Exchangeable bases (cmol kg^{-1})			
Ca^{2+}	5.20	2.80	3.60
Mg^{2+}	1.06	0.37	0.46
K^{+}	0.33	0.29	0.23
Na^{+}	2.78	2.17	2.87
Exchangeable acidity			
$H^{+} + Al^{3+}$	0.80	0.60	0.60
CEC	12.30	7.80	9.70

Table 2. Rainfall amount and distribution during the period of experiment at Samaru, Nigeria.

	Rainfall amount (mm)		
Month	2009	2010	2011
July	285.0	216.8	223.9
August	439.7	313.4	239.9
September	206.7	211.2	113.8
October	151.7	82.3	54.0
Total	1083.1	823.7	631.6

Source: Meteorological Station, Institute for Agricultural Research, Samaru, Nigeria. Reproduced by permission of Meteorological Unit, Institute for Agricultural Research, Samaru, Zaria, Nigeria.

Table 3.Effect of seed and nitrogen rates on weed biomass (gm^{-2}) of two sesame varieties in 2009, 2010 and 2011 rainy seasons at Samaru.

Treatment	2009			2010			2011			Combined mean		
	3WAS	6WAS	9 WAS	3 WAS	6WAS	9 WAS	3 WAS	6 WAS	9 WAS	3 WAS	6 WAS	9 WAS
Variety (V)												
NCRIBEN 01M	70.6	41.4	90.8	9.6	82.6	20.8	6.0	12.8	4.0	28.7	45.6	[illegible]
E8	65.4	32.0	74.0	11.3	78.0	19.6	9.3	15.5	4.2	28.6	41.8	[illegible]
LSD (0.05)	8.0	7.1	9.7	1.4	15.1	3.4	2.0	2.0	0.9	2.9	3.7	[illegible]
Seed rate (S) (kg ha^{-1})												
2	56.4	29.6	75.3	9.6	59.0	16.9	7.0	11.2	4.4	24.3	33.3	[illegible]
4	64.6	41.9	74.1	9.1	80.5	20.8	7.2	13.4	3.6	27.0	45.3	[illegible]
6	74.7	37.6	95.7	10.0	86.8	21.7	8.8	15.5	4.1	33.3	46.6	[illegible]
8	76.1	37.9	82.4	12.9	94.7	21.2	7.9	16.4	4.5	32.3	49.7	[illegible]
LSD (0.05)	15.4	10.0	14.0	2.3	21.4	4.8	2.9	2.9	1.1	4.0	5.1	[illegible]
Nitrogen rate (N) (kg ha^{-1})												
0	63.6	31.7	82.0	9.2	94.0	20.7	8.0	15.6	4.5	26.9	47.1	[illegible]
30	69.5	35.4	81.4	10.6	79.4	21.8	7.2	15.0	4.2	29.1	43.3	[illegible]
60	73.6	38.0	81.7	10.6	75.2	19.9	8.0	12.4	4.0	30.7	41.9	[illegible]
90	65.1	41.8	84.3	11.2	72.4	18.3	7.4	13.6	4.1	27.9	42.6	[illegible]
LSD (0.05)	15.4	10.0	14.0	2.3	21.4	4.8	2.9	2.9	1.1	4.0	5.1	[illegible]
Interaction												
V×S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
V×N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S×N	*	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS
V×S×N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

WAS – week after sowingNS – not significant *Significant

Table 4. Interaction between seed and nitrogen rates on weed biomass (g m^{-2}) at 3 WAS in sesame in 2009 and 2010.

	Nitrogen (kg ha^{-1})			
Treatment	0	30	60	90
Seed rate (kg ha^{-1})		2009		
2	65.6	73.8	44.6	42.0
4	66.9	47.3	62.2	81.8
6	57.2	64.6	90.6	86.3
8	64.6	92.4	97.1	50.0
LSD (0.05)		30.8		
		2010		
2	8.8	9.1	9.0	11.4
4	6.8	7.2	9.7	12.8
6	6.0	10.8	13.0	10.4
8	15.4	15.4	11.0	10.1
LSD (0.05)		4.3		

Table 5. Effect of seed and nitrogen rates on plant height of two sesame varieties at 12 WAS in 2009-2011 rainy season at Samaru.

	Plant height (cm)			
Treatment	2009	2010	2011	Combined mean
Variety (V)				
NCRIBEN 01M	105.0	85.3	108.5	99.6
E8	106.5	90.3	106.1	100.9
LSD (0.05)	8.8	4.0	4.3	4.6
Seed rate (S) (kg ha^{-1})				
2	99.0	82.3	86.4	89.2
4	111.7	80.0	106.7	99.4
6	105.4	89.6	114.3	103.1
8	106.8	99.3	121.8	109.3
LSD (0.05)	12.5	5.7	6.0	6.3
Nitrogen rate (N) (kg ha^{-1})				
0	99.4	75.9	103.14	92.9
30	108.2	84.2	106.7	99.7
60	101.6	92.3	107.0	100.3
90	113.7	98.6	112.2	108.2
LSD (0.05)	12.5	5.7	6.0	6.3
Interaction				
V×S	NS	NS	NS	NS
V×N	NS	NS	NS	NS
S×N	NS	NS	NS	NS
V×S×N	NS	NS	NS	NS

WAS – weeks after sowingNS – not significant

Table 6. Effect of seed and nitrogen rates on number of capsules per plant of two sesame varieties in 2009-2011 rainy seasons at Samaru.

Treatment	Number of capsules per plant			
	2009	2010	2011	Combined mean
Variety (V)				
NCRIBEN 01M	26	20	31	26
E8	25	20	29	25
LSD (0.05)	2.6	1.1	0.9	1.7
Seed rate (S) (kg ha^{-1})				
2	19	16	20	18
4	26	19	27	24
6	26	19	34	26
8	29	26	39	31
LSD (0.05)	3.7	1.7	1.4	2.6
Nitrogen rate (N) (kg ha^{-1})				
0	21	16	25	21
30	26	19	27	24
60	26	20	30	25
90	27	25	38	30
LSD (0.05)	3.7	1.7	1.4	2.6
Interaction				
V×S	NS	*	*	NS
V×N	NS	NS	NS	NS
S×N	*	*	*	*
V×S×N	NS	NS	NS	NS

WAS – weeks after sowing NS – not significant *Significant

Table 7. Interaction between seed rates and variety on number of capsules per sesame plant in 2010 and 2011 rainy seasons at Samaru.

Treatment	Variety	
	NCRIBEN 01M	E8
Seed rate (kg ha^{-1})	2010	
2	16	17
4	19	18
6	18	20
8	28	25
LSD (0.05)	2.9	
	2011	
2	19	21
4	27	26
6	36	32
8	42	36
LSD (0.05)	2.9	

Table 8. Interaction between seed and nitrogen rates on number of capsules per sesame plant in 2009, 2010, 2011 and combined

Treatment	Nitrogen (kg ha^{-1})			
	0	30	60	90
Seed rate (kg ha^{-1})		2009		
2	12	17	22	28
4	27	24	22	33
6	18	29	31	24
8	28	35	29	24
LSD (0.05)		7.4		
		2010		
2	10	15	19	22
4	18	21	19	15
6	21	18	18	19
8	15	22	25	43
LSD (0.05)		3.4		
		2011		
2	13	19	22	26
4	30	25	27	24
6	25	31	34	47
8	31	33	37	53
LSD (0.05)		2.9		
		Combined		
2	12	17	21	25
4	25	23	23	24
6	21	26	28	30
8	25	30	31	40
LSD (0.05)		5.1		

Table 9. Effect of seed and nitrogen rates on seed yield of two sesame varieties in the rainy seasons of 2009, 2010, 2011 and combined at Samaru

	Seed yield (kg ha^{-1})			
Treatment	2009	2010	2011	Combined mean
Variety (V)				
NCRIBEN 01M	180.9	280.1	492.8	317.9
E8	229.0	363.4	427.0	339.8
LSD (0.05)	47.6	17.7	6.8	20.8
Seed rate (S) (kg ha^{-1})				
2	41.9	209.9	204.7	152.2
4	135.7	276.1	473.6	295.1
6	255.0	337.4	550.8	381.1
8	387.3	463.8	610.6	487.2
LSD (0.05)	67.5	24.8	9.7	29.6
Nitrogen rate (N) (kg ha^{-1})				
0	150.4	158.6	353.9	221.0
30	184.8	242.2	427.0	284.6
60	240.6	427.9	476.5	381.7
90	244.1	458.4	582.3	428.3
LSD (0.05)	67.5	24.8	9.7	29.6
Interaction				
V×S	NS	NS	NS	NS
V×N	NS	NS	NS	NS
S×N	NS	*	*	*
V×S×N	NS	*	*	NS

WAS – weeks after sowing NS – not significant *Significant

Table 10. Interaction between seed and nitrogen rates on seed yield (kg ha^{-1}) of sesame in 2010, 2011 and combined mean

Treatment	Nitrogen (kg ha^{-1})			
	0	30	60	90
Seed rate (kg ha^{-1})		2010		
2	41.9	130.8	394.8	272.1
4	142.0	220.2	447.7	294.3
6	204.9	264.7	376.2	503.8
8	245.8	352.9	493.0	763.3
LSD (0.05)		49.9		
		2011		
2	123.8	183.1	229.6	282.4
4	344.2	444.5	474.8	630.8
6	452.6	526.9	572.1	651.5
8	494.8	553.6	629.7	764.4
LSD (0.05)		19.4		
		Combined mean		
2	58.8	118.6	222.6	208.6
4	209.2	255.0	349.7	366.5
6	278.2	329.6	431.8	484.6
8	337.6	435.3	522.6	653.3
LSD (0.05)		59.0		

Table 11. Interaction between variety, seed and nitrogen rates on seed yield of sesame (kg ha^{-1}) in 2010 and 2011.

		Variety			
Seed rate (kg ha^{-1})	Nitrogen rate (kg ha^{-1})	NCRIBEN 01M	E8	NCRIBEN 01M	E8
		2010		2011	
2	0	36.7	47.0	151.6	96.0
	30	129.9	131.7	201.2	165.0
	60	323.5	466.1	239.7	219.6
	90	268.5	275.7	288.1	276.6
4	0	117.9	166.1	408.0	280.5
	30	162.7	277.7	474.6	414.4
	60	396.3	499.1	508.4	441.1
	90	289.1	299.5	628.7	632.9
6	0	146.2	263.3	487.0	418.3
	30	189.1	340.2	579.3	474.5
	60	355.6	396.7	627.8	516.4
	90	443.2	564.3	732.6	570.3
8	0	145.8	345.7	553.6	436.0
	30	274.9	430.9	603.6	503.6
	60	501.9	484.1	649.3	610.1
	90	700.6	826.1	751.8	776.9
LSD (0.05)		70.4		27.4	

Discussion

The soils of the experimental site were characterized by low concentration of some of the essential nutrients particularly total nitrogen, organic carbon and acidity. These results conform to the findings of Haruna *et al.* (2011), who reported that soils of the study area are low in soil pH, organic matter, nitrogen and available phosphorus. However the high level of total nitrogen in the experimental site in 2011 could be attributed to the residual effect of groundnut as the previous crop. Across the experimental site and years, rainfall amount and distribution was adequate to support general performance of sesame.

Reduction in weed biomass produced varied between the sesame varieties. However, weed biomass was most reduced across the years at the peak of sesame growth with variety E8. This further confirmed the exacerbation that sesame varieties differ in their ability to control emerging weed seedlings (Kolo and Daniya 2006). Variety E8 significantly out performed NCRIBEN 01M in terms of taller plants at 12 WAS in 2010, seed yield per ha^{-1} in 2010 and the combined; while variety NCRIBEN 01M out performed variety E8 in terms of number of capsules per plant, and seed yield per hectare in 2011. The variation and inconsistencies recorded between the varieties in producing the highest growth and yield parameters could be attributed to the differences in the soil physical and chemical conditions or variation in the climatic condition of the site in all seasons. These results confirm the findings of Sharar *et al.* (2000).

Weed control was generally better when plants were grown at 2 kg seeds ha^{-1}. This could be attributed to better vegetative growth due to available space and resource utilization (Caliskan *et al.*, 2004) and this might have easily formed canopies which shaded off weeds than those at higher seed rates. This finding is also in agreement with the findings of Imoloame *et al.* (2007) who observed higher amount of weeds in sesame plots sown at higher seed rates.

The use of 8 kg seed ha^{-1} enhanced growth through increased plant height. The increase in plant height at these densities could be attributed to intra specific competition for crop growth resources by the sesame plants; which resulted in elongation of internodes and into taller plants. A similar finding in sesame was earlier reported by Noorka *et al.* (2011). The production of more capsules per plant at 4 kg seed ha^{-1} in 2009, and 8 kg seed ha^{-1} in 2010, 2011 and combined in this study could be attributed to the taller plants observed which translated into more nodes from where leaves are produced (Haggai *et al.*, 2003). These in turn probably led to the formation of more capsules from the leaf axils at these densities (Langham, 2007). The increase in seed yields ha^{-1} with the use of 8 kg seed ha^{-1} might be attributed to more plants per unit area as earlier reported by Noorka *et al.* (2011).

The non-significant effect of N rates on weed biomass produced might be due to the method of fertilizer application. The present result is in agreement with Togay *et al.* (2009) who observed that broadcast method of applying fertilizer was more effective in enhancing weed growth than deep banded placement method. In our study, N fertilizer was subsurface applied at 5 cm deep by the side of the seed and plant rows. Therefore N fertilizer did not enhance weed growth to the detriment of sesame growth and yield. This study demonstrated that sesame had a competitive advantage when N was subsurfaced applied, whereby it was stimulated to grow luxuriantly, while the emergence of weed species at this stage were made to succumb to the shading effect of the sesame plant canopy. The increase in plant height with application of 30 to 90 kg N ha^{-1} in this study could be attributed to the ability of nitrogen to stimulate cell division and extension which in turn increased the length of internodes that translated into taller plants. This result agreed with Haggai *et al.* (2003) who found that plant height was increased by adding N fertilizer up to 90 kg N ha^{-1}. Numbers of capsules and seed yields were all enhanced by the application of the highest N level of 90 kg N ha^{-1}; which in most cases were comparable to those of 30 and 60 kg N ha^{-1}. These increases might be attributed to the role played by N in stimulating plant growth and development. These results are in line with those reported by Olowe and Busari (2000), Haggai (2004) and Noorka *et al.* (2011) with the application of 90 kg N ha^{-1} and 205 kg N ha^{-1}, respectively.

The interaction between variety and seed rate on number of capsules per plant revealed that 8 kg seed ha^{-1} in both varieties in 2010, and 8 kg seed ha^{-1} with variety NCRIBEN 01M in 2011 had the highest number of capsules per plant. This could be attributed to the taller plants produced at this density; which might have produced more internodes from where the capsules were formed from the leaf axils (Langham, 2007).

The interaction between seed and nitrogen rates on number of capsules affirmed that either seed and nitrogen rates, or combined use of seed and nitrogen rates such as 8 kg seed ha^{-1} with application of 90 kg N ha^{-1} is essential in production of greater number of capsules in sesame production.

The interaction between seed and nitrogen rates on seed yield clearly demonstrated that number of capsule is an attribute of sesame seed yield. In this study the highest seed yield obtained with the use of 8 kg seed ha^{-1} in conjunction with 90 kg N ha^{-1} could probably be due to greater number of plants per unit area and the role of nitrogen on crop growth. Noorka *et al.* (2011) also reported an increasing seed yield with increasing plant population density and at the highest available N rate.

The highest seed yield obtained with variety E8 in combination with 8 kg seed ha^{-1} and 90 kg N ha^{-1}, clearly showed the importance of selecting a tolerant and high yielding variety, seed and nitrogen rates in sesame production. The high yielding ability of variety E8 compared to other sesame varieties had earlier been reported by Olowe and Adeoniregun (2010). Moreover, the increase in seed yield with increase in plant density and nitrogen supply had been observed by Noorka *et al.* (2011).

From this research, it can be concluded that the use of 8 kg seed ha^{-1} with application of 90 kg N ha^{-1} and variety E8 gave the maximum seed yield; and is therefore recommended for considerable yield increase in sesame production in the Northern Guinea savannah of Nigeria. The selection of a variety in combination with seed rate and N fertilization may be an important component for weed management and will possibly increase sesame production.

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