Agronomic Efficiency of N, P and K Fertilization in sesame (*Sesamum indicum*) in Mubi Region, Adamawa State, Nigeria

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Abstract: A pot experiment was conducted in the screen house at the FAO/TCP teaching and research farm of the Adamawa State University, Mubi to assess the soil N, P and K fertilizer requirement of sesame (*Sesamum indicum* L.). N, P and K fertilization at 75 kg N, 45 kg P_2O_5 and 22.5 kg K_2O ha^{-1} gave the highest seed yield of 456 kg ha^{-1} while dry matter yield was highest (1460 kg ha^{-1}) at 112.5 kg N, 45 kg P_2O_5 and 45 kg K_2O ha^{-1}). Highest dry matter nutrient ratio (20.1) and seed nutrient ratio (3.7) was obtained at 37.5 kg N ha^{-1} and 22.5 kg P_2O_5 ha^{-1} respectively. VCR (2.3) was highest at 75 kg N ha^{-1} with net return of N21,630 (US$147.14). The highest seed yield had value cost ratio of 1.5 with corresponding net return of N29,000 (US $197.28). VCR more than 2.0 that shows satisfactory risk coverage against investment in fertilizer use were N at 37.5, 75, 112.5 kg N ha^{-1} and N and K combination of 75 kg N and 22.5 kg K ha^{-1}. Fertilization of K alone is not economical as it recorded the list VCR (0.1-0.5) and should be added for the purpose of nutritional balance. [Nature and Science 2010;8(8):257-260]. (ISSN: 1545-0740).

Keywords: Nitrogen; Phosphorus; Potassium; Agronomic efficiency; Value cost ratio

1. Introduction

Sesame or benniseed (*Sesamum indicum* L.) is cultivated in almost all tropical and sub tropical Asia and African countries for its highly nutritious and edible seeds. (Iwo et al., 2002). It is potentially capable of producing large quantities of seeds per unit area but low yield ha^{-1} (Ahmad et al., 2001) and improper fertilization (Rao et al, 1994). In Nigeria, it is cultivated in the derived, northern and southern guinea, sudan and sahel savanna zones. (Alegbejo et al, 2003). For many years, sesame yields in Nigeria remained very low due to non practice of fertilization by the traditional sesame growers. However, higher yields were obtained from the application of nitrogen (N), phosphorus (P) and sulpher (S) in Burkina Fasso (Rao et al, 1994 and Scilling and Cattan, 1991). Similarly, Ahmad et al (2001) reported increase in sesame seed yield from N and P fertilization and non increase due to K fertilization.

Although knowledge of some agronomic practices in northern Nigeria has been reported, information on its nutritional and agronomic efficiencies is limited. Therefore, a screen house study was conducted to assess the agronomic efficiencies of N, P and K fertilizers in sesame production, its economic investment potentials and risk management.

2. Materials and Methods

A 4 x 3 x 3 factorial experiment was conducted in the screen house of the FAO/TCP farm of the Adamawa State University, Mubi, Nigeria (10° 15' N, 13° 16' E and 696 m above sea level) to study the effect of nitrogen, phosphorus and potassium on the nutrition of sesame (*Sesamum indicum L.*). The experiment consists of 4 nitrogen rates (0, 18.75, 37.5, 56.25 mg N kg^{-1} soil or 0, 37.5, 75 and 112.5 kg ha^{-1}), 3 phosphorus rates (0, 11.25 and 22.5 mg P_2O_5 kg^{-1} soil or 0, 22.5 and 45 kg ha^{-1}) and 3 rates of potassium (0, 11.25 and 22.5 mg K_2O kg^{-1} soil or 0, 22.5 and 45 kg ha^{-1}). The 36 treatments were replicated 3 times, arranged in completely randomized design (CRD). N, P and K sources were from ammonium nitrate, calcium dihydrogen phosphate and potassium chloride salts, respectively.

Top soil (0-15 cm) was collected from the experimental site, air dried and sieved through a 2 mm screen. The soil was analysed in the laboratory for some physical and chemical characteristics by standard methods. The characteristics of the experimental soil were, pH (5.8, 1:2.5 H_2O), organic matter (0.75 g kg^{-1}), total N (0.15 g kg^{-1}), available P (7.3 mg kg^{-1}) and exchangeable K (3.2 cmol kg^{-1}) and the textural class is sandy loam (Sand, silt and clay were 53.6, 30.2 and 16.2 g kg^{-1} respectively). Five kg of the soil was placed in plastic pots and five seeds per pot were sown evenly. The plants were irrigated to 75% equivalent to 790 cm^3 of water. Harvesting was done after the pods were mature. Growth and yield characters were determined. Data collected was subjected to analysis of variance (ANOVA). Duncan's Multiple Range Test (DMRT) was used for mean separation where differences were significant, at 5% level of probability. Agronomic efficiency and variable cost ratio were calculated using the following formulae.

Agronomic Efficiency:

Dry Matter or Seed Nutrient

$$\textit{Ratio (DNR or SNR)} = \frac{\textit{Increase in yield}}{\textit{Nutrient applied}}$$

Variable Cost

$$\textit{Ratio (VCR)} = \frac{\textit{Value of increased yield}}{\textit{Cost of fertilizer used}}$$

Prices of urea, single superphosphate (SSP) and muriate of potash (MOP) were used as sources of N, P and K respectively.

Table 1: Sesame dry matter yield as influenced by N, P and K fertilization.

N rate	P rate	K rate (kg ha^{-1}) 0				22.5				45			
(kg ha^{-1})		Y	YI	%	DNR	Y	YI	%	DNR	Y	YI	%	DNR
0	0	529^{l}				539^{l}	10	2	0.4	532^{l}	3	1	0.1
	22.5	891^{k}	362	68	16.1	851^{k}	322	61	7.2	930^{i-k}	401	76	5.9
	45	1103^{d-k}	574	109	12.6	1041^{d-k}	512	97	7.6	1008^{e-k}	479	91	5.3
37.5	0	1283^{c-i}	754	143	20.1	923^{i-k}	394	74	6.6	947^{h-k}	418	79	5.1
	22.5	900^{jk}	371	70	6.2	979^{f-i}	450	85	5.5	1150^{c-j}	621	117	5.9
	45	1022^{d-k}	493	93	6.0	901^{jk}	372	70	3.5	1208^{ab}	679	128	5.3
75	0	1273^{a-d}	744	141	9.9	1411^{ab}	882	167	9.0	1047^{d-k}	518	98	4.3
	22.5	1276^{a-c}	371	141	7.7	1208^{a-g}	679	128	5.7	1226^{a-f}	697	132	4.9
	45	1258^{a-e}	493	138	6.1	1399^{a-c}	870	164	6.1	1229^{a-f}	700	132	4.2
112.5	0	1224^{a-f}	695	131	6.2	1189^{b-h}	660	125	4.9	1178^{b-i}	649	123	4.1
	22.5	1414^{ab}	885	167	6.6	1416^{ab}	887	168	5.6	1259^{a-e}	730	138	4.1
	45	1427^{ab}	898	170	5.7	1413^{ab}	884	167	4.9	1460^{a}	931	176	4.6

Y= Yield, YI= Yield increase, DNR= Dry matter nutrient ratio

Means followed by the same letter(s) are not significantly different at 5% level of probability using Duncan Multiple Range Test.

Table 2: Sesame seed yield and agronomic efficiency of N, P and K rates.

N rate	P rate	K rate (kg ha^{-1}) 0				22.5				45			
Kg ha^{-1}		Y	YI	%	SNR	Y	YI	%	SNR	Y	YI	%	SNR
0	0	184^{k}				188^{k}	4	10	0.8	198^{k}	14	6	0.3
	22.5	268^{i-k}	84	46	3.7	240^{jk}	56	30	1.2	286^{g-k}	102	55	1.5
	45	342^{a-i}	158	86	3.5	288^{g-k}	104	57	1.5	320^{a-i}	136	74	1.5
37.5	0	263^{b-i}	79	43	2.1	296^{a-c}	112	61	1.9	309^{e-i}	125	68	1.5
	22.5	278^{b-k}	94	51	1.6	321^{c-i}	137	74	1.7	387^{b-f}	203	110	1.9
	45	340^{b-i}	156	85	1.9	336^{e-i}	152	83	1.4	434^{ab}	250	136	2.0
75	0	389^{a-e}	205	111	2.7	373^{a-h}	189	102	1.9	328^{c-i}	144	78	1.2
	22.5	350^{b-i}	166	90	1.7	374^{a-h}	190	103	1.6	354^{b-i}	170	92	1.2
	45	373^{a-h}	189	103	1.6	456^{a}	272	148	1.9	360^{a-h}	176	96	1.1
112.5	0	429^{ab}	245	133	2.2	342^{b-i}	158	86	1.2	373^{a-h}	189	103	1.2
	22.5	363^{a-i}	179	97	1.3	377^{a-h}	193	105	1.2	364^{a-i}	180	98	1.0
	45	382^{a-g}	198	108	1.3	409^{a-d}	225	122	1.3	411^{a-d}	227	123	1.1

Y= Seed yield, YI= yield increase, SNR= Seed nutrient ratio

Means followed by the same letter(s) in each treatment group are not significantly different at 5% level of probability using Duncan Multiple Range Test.

3. Results and Discussion

3.1 Sesame yield response to N, P and K fertilization

Results (Table 1) shows that increase in N rate increased dry matter yield up to 112.5 kg N ha^{-1} but the rate of increase decreased from 143% at 37.5 kg N ha^{-1} to 131% at 112.5 kg ha^{-1}. Dry matter yield also increased linearly with increase in P rate from 68% at 22.5 kg P_2O_5 ha^{-1} to 109% at 45 kg P_2O_5 kg ha^{-1}. K fertilization decreased dry matter yield from 2% at 22.5 kg K_2O ha^{-1} to 1% at 45 kg K_2O ha^{-1}. N, P and K fertilization at 112.5 kg N, 45 kg P_2O_5 and 45 kg K_2O ha^{-1} produced the highest dry matter yield of 1460 kg ha^{-1} with corresponding increase of 1.8 folds over control. This is followed by 1427, 1416, 1414, 1413 and 1411 kg ha^{-1} obtained from N, P and K interaction at 112.5 kg N and 45 kg P_2O_5 kg ha^{-1}, 112.5 kg N, 22.5 kg P_2O_5 and 22.5 kg K_2O kg ha^{-1}, 112.5 Kg N and 22.5 P_2O_5 ha^{-1}, 112.5 kg N, 45 kg P_2O_5, and 22.5 kg K_2O ha^{-1} and 75 kg N, 0 kg P_2O_5 kg and 22.5 kg K_2O ha^{-1} respectively.

Table 3: Economic analysis of N, P and K fertilization of sesame

N rate	P rate	K rate (kg ha^{-1}) 0				22.5				45			
Kg ha^{-1}		GR	EF	NR	VCR	GR	EF	NR	VCR	GR	EF	NR	VCR
0	0	21160				22330	2250	1170	0.5	21780	4500	620	0.1
	22.5	29480	4250	8320	2.0	26400	6150	5240	0.8	31460	8750	10300	1.2
	45	37620	8500	16460	1.9	31680	10750	10250	1.0	35200	17250	14040	0.8
37.5	0	30245	4075	9085	2.2	32560	6325	11400	1.8	33990	8575	12830	1.5
	22.5	30580	8325	9420	1.1	35310	10575	14150	1.3	42790	12825	21630	1.7
	45	37400	12575	16240	1.3	36960	14825	15800	1.1	47740	17075	26580	1.6
75	0	42790	8150	21630	2.3	43015	10400	21840	2.1	36080	12650	14920	1.2
	22.5	38500	12400	17340	1.4	41140	14650	19980	1.4	38940	16900	17780	1.1
	45	41030	16650	19870	1.2	50160	18900	29000	1.5	39600	21150	18440	0.9
112.5	0	47190	12225	26030	2.1	37620	14475	16400	1.1	41030	16725	19870	1.0
	22.5	39930	16475	18770	1.1	41470	18725	20310	1.1	40040	20975	18880	0.9
	45	42020	20725	20860	1.0	44990	22975	23830	1.0	45210	25225	24050	1.0

GR= Gross return, EF= Expenditure on fertilizer, NR= Net return, VCR= Value cost ratio
Price of sesame= ₦115 kg^{-1}, Price of urea, SSP and MOP= ₦2500, 1700 and 3000 bag^{-1} respectively. Exchange rate is ₦147 to US $1

Seed yield increased linearly from increased N and P rates. Seed yield increases were 43, 111, and 133% over control at 37.5, 75 and 112.5 kg N ha^{-1} fertilization. For P fertilization, increase was from 46% to 86% at 22.5 and 45 kg P_2O_5 ha^{-1} fertilization respectively. K fertilization decreased seed yield by 4% at 45 kg K ha^{-1}. Highest seed yield increase from N, P and K interaction was 1.5 folds the control.

Application of N and P fertilizers to sesame increased dry matter and seed yields of sesame which is in agreement with the findings of Taylor et al (1981), Schilling and Cattan (1991) and Malik et al (2003). Significant increase in dry matter yield of sesame up to 112.5 kg N ha^{-1} shows that increase was at the expense of seed yield which was optimum at 75 kg N ha^{-1} fertilization. Similar results had been reported by Okpara et al (2007). Negative response of seed yield to K fertilization agrees with the reports of El-Emam et al (1998) and at variance with Jung (1991).

3.2 Agronomic efficiency of N, P and K

Agronomic efficiencies of N, P and K as shown in Tables 1 & 2 indicates that the highest dry matter nutrient ratio (DNR) of 20.1 is obtained at 37.5 kg N ha^{-1} fertilization followed by 16.1, 9.9 and 9.0 from 22.5 kg P_2O_5, 75 kg N, and 75 kg N and 22.5 kg K_2O ha^{-1} respectively. The lowest was 0.1 at 45 kg K_2O ha^{-1}. The seed nutrient ratio (SNR) at 22.5 kg P_2O_5 was highest (3.7) followed by 3.5, 2.7 and 2.6 at 45 kg P_2O_5, 75 kg N, and 75 kg N and 22.5 kg K_2O ha^{-1} respectively while the lowest (0.3) was also at 45 kg K_2O ha^{-1}. This is expected since there was decrease in seed yield at this rate. These responses indicate the role of P in seed formation as N plays major role in vegetative production.

3.3 Economic analysis of N, P and K fertilization of sesame

The value cost ratio (VCR) of N, P and K fertilization (Table 3) indicates that it ranged from 0.9 to 1.7. For N alone, it ranged from 2.1 to 2.3 and P, from 1.9 to 2.1 while K is from 0.1 to 0.5. That of N and P ranged from 1.0 to 1.4, N and K is from 1.0 to 2.5 as P and K is from 0.8 to 1.2. This shows that N followed by P plays a major role in providing

satisfactory risk management against investment in fertilizer application.

4. Conclusion

Based on the results obtained from this study, it is concluded that the optimum seed yield was obtained from N, P and K fertilization at 75 kg N, 45 kg P_2O_5 and 22.5 kg K_2O ha^{-1} with highest NR of N29,000 (US$197.28). VCR more than 2.0 that shows satisfactory risk coverage against investment in fertilizer use were N at 37.5, 75, 112.5 kg N ha^{-1} and N and K combination of 75 kg N and 22.5 kg K ha^{-1}. K fertilization is not economical due to least VCR which ranged from 0.1 to 0.5 but can be added for the purpose of nutrient balance. It is suggested that this study should also de conducted under field conditions.

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