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Research Article

Effect of Nitrogen and Phosphorus on Yield and Yield Components of Sesame (Sesamum Indicum L.) at Kamashi Zone of Benshangul Gumuz under Balanced Fertilizer

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ABSTRACT

Sesame is one of the heavy feeders of nutrients to produce high and quality yields among oil crops. Application of fertilizers in relation to initial soil fertility status and crop requirement leads to economic and judicious use of fertilizers. Hence, the study was conducted on Sesame crop at Kamashi area in Benshangul Gumuz of Nitisols. The experiment was arranged in randomized complete block design with 4 levels of Nitrogen (0,23,46 and 69 N kg $ha^{-1}$and three levels of phosphorous fertilizer (0,10, and 20 kg P ha^{-1} in factorial arrangement with three replications. Results showed that seed yield of sesame significantly affected by N and P fertilizer application rate. The higher mean yield (998.9kg ha^{-1}) was obtained from 46 N and 10P kg ha^{-1} interaction, however, the lower mean yield was recorded from the control. Comparing the yield of sesame application of 46N and 10P kg ha^{-1} had improved the seed yield of sesame by 248.0% compared to the control. The profitability of the study showed that application of 46 N and10 Pkg ha^{-1} which provided that relatively highest net benefit (29,502.8ETB), were the peak to apply fertilizers.

Keywords: Sesame, Soil fertility;Agricultural;Fertilizers

INTRODUCTION

Sesame (*SesamumindicumL.*) belongs to family pedaliaceae is an annual, self-pollinated and indeterminate minor oilseed crop. The stem is variously shaped, 60-120 cm tall and branched. The fruit is in the form of pods varies from 2.5 to 8.0 cm in length and 0.5 to 2.0 cm in diameter. Pods mature form bottom to top, allowing shattering of the lower ones by the time the uppermost pods are mature. Sesame seed are small and ovate with two distinct types, cream-colored and black. It is a short-day plant, normally flowering in 42-45 days.

Low soil fertility is one of the bottlenecks to sustain agricultural production and productivity in Ethiopia. Thus, sesame is one of the heavyfeeders of nutrients to produce high and quality yields among oil crops. Application of balanced fertilizers is the basis to produce more crop output from existing land under cultivation and nutrient needs of crops is according to their physiological requirements and expected yields [1]. Continuous cultivation of most of Ethiopian soils with application of only N and P containing fertilizers may cause reduction of the quantity of other nutrients from the soils such as potassium (K) and sulphur (S) ATA, [2]. In addition these nutrients might be lost via fixation of potassium and leaching of sulphur in different types of soils [3]. Therefore, application of other sources of nutrients beyond Urea and Diammonium Phosphate (DAP), especially those containing K,S,Zn and other micro-nutrients could increase crop productivity [4]. This can be achieved by application of blended fertilizers, the mechanical mixture of two or more granular fertilizer materials containing N, P, K and other essential plant nutrients such as S, Zn, and B, recently known to Ethiopia.

Application of fertilizers in relation to initial soil fertility status and crop requirement leads to economic and judicious use of fertilizers. Experiments conducted by different researchers to decide rate of fertilizer under different research stations and their surrounding on-farm resulted in different rates of recommendations in terms of both N and P [5]. Nutrient mining due to sub optimal fertilizer use in one hand and unbalanced fertilizer uses on other have favored the emergence of multi nutrient deficiency in Ethiopian. Different research reports indicate that nutrients like K, S, Ca, Mg and all micro-nutrients except Fe are becoming depleted and deficiency symptoms are being observed on major crops in different areas of the country [6]. Recently acquired soil inventory data from EthioSIS (Ethiopian Soil Information System) also revealed that in addition to N and P, nutrients such as S, B, Zn are widespread in Ethiopian soils. EthioSIS (Ethiopian Soil Information System) indicated that, the soils of Kameshi area also deficient in, sulphur

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and potassium in addition to phosphorous and nitrogen, which all potentially hold back crop productivity despite continued use of N and P fertilizer as per the blanket recommendation. According to Bekabil, the lack of appropriate fertilizer blends and lack of micronutrients in fertilizer blends are the national problem which is major constraints to crop productivity. It is imperative to increase the productivity along with desirable attributes through production management practices and application of other sources of nutrients beyond the blanket recommendation of Urea and DAP, especially those that contain potassium, sulphur and other micro-nutrients [4]. Therefore, the present study was designed to assess the effects of N and P rates under balanced fertilizer (S &K) of nutrient on sesame production in Asossa.

MATERIALS AND METHODS

Description of the Study Site

The study was carried out at Kamashizone in Benshangul Gumuze Regional State.Geographically, it is an altitude of 1560 meters above sea level. Agro-climatically, it has been characterized by hot to warm moist lowland plain with uni-modal rainfall distribution pattern. The rainy season starts at the end of April and lasts at the end of October with maximum rainfall from June to October. The mean annual rainfall of the years (2016-2018) was 1510.813mm. The mean annual minimum and maximum temperatures of the area for the same years were 18.12and 30.9°C, respectively. The amount of rainfall observed during the growing year was showed (Figure 1).

Experimental Treatments, Design, and Procedures

The fertilizer treatments considered in the study consisted of four levels of level of N (0, 23, 46 and 69 kgha^{-1}) and 3 Levels of P (0, 10, and 20 kgha^{-1} P) with a total of twelve treatment combinations. All plot uniformly received the required dose of sulfur and potassium for the test crop and fertilizer source of $CaSO_4$ and KCl respectively. The experiment was then conducted using a factorial experiment laid out in a randomized complete block design with three replications. A 2.4*3m (7.2m^2) plot size was used as an experimental unit. A composite soil sample (0-20cm) was collected from the site for laboratory analysis before land preparation. The blocks were separated by a 1.5 m wide open space where as the plots within a block were separated by a 0.75m wide space. Soil bunds were constructed around each plot and around the entire experimental field to minimize nutrient and water movement from plot to plot. Planting was made on 20 June 2016 and 2018 by hand drilling the seeds in rows spaced 30 cm apart. Nitrogen was applied in two equal splits, where in 50% of the N rate was applied basal at planting and the remaining half was top dressed at the maximum branching stage which occurred 35-45 days after germination, as urea (46% N). Unlike N, the total dose of P was applied basal as triple super phosphate (20% P) during sowing.Weed control was manual mainly by hand picking. Crop growth was then monitored until harvest.

Soil Sampling and Analysis

Before the commencement of the experiment, a composite soil sample was taken from the upper 0-20cm of the experimental field and analyzed for selected physical and chemical properties. Soil pH was determined using a pH meter with combined glass electrode in water (H_2O) at 1:2.5 soil: water ratio as described by Carter (1993). Organic carbon, was determined by oxidizing carbon with potassium dichromate in sulfuric acid solution following the Walkley and Black method. The total nitrogen contents in soils were determined using the Kjeldahl procedure by oxidizing the organic matter with sulfuric acid and converting the nitrogen into NH_4^+ as ammonium sulfate [6]. Exchangeable acidity was determined by saturating the soil samples with potassium chloride solution and titrated with sodium hydroxide as described by Mclean [7]. Available phosphorus was determined in Bray-II method.

Finally exchangeable bases (Ca,Mg,K and Na) in the soil were estimated by the ammonium acetate (1M NH_4OAc at pH 7) extraction method. In this procedure, the soil samples were extracted with excess of NH_4OAc solution, and Ca and Mg in the extracts were determined by atomic absorption spectrophotometer, while flame photometer was used to determine the contents of exchangeable K and Na as described by Rowell [8].

Economic Analysis

Mean grain yield of the selected treatment was used in partial budget analysis [9-13]. Economic analysis was performed to investigate the economic feasibility of the treatments (fertilizer rates). A partial budget, dominance and marginal analysis were used.The average open market price (Birr kg^{-1}) for maize and the official prices of blended, Urea and TSP fertilizers were used for economic analysis. The dominance analysis procedure as detailed in CIMMYT [9] was used to select potentially profitable treatments from the range that was tested. The selected and discarded treatments using this technique are referred to as undominated and Dominated' treatments, respectively. The undominated treatments were ranked from the lowest (the farmers' practice) to the highest cost treatment. For each pair of ranked treatments, a % marginal rate

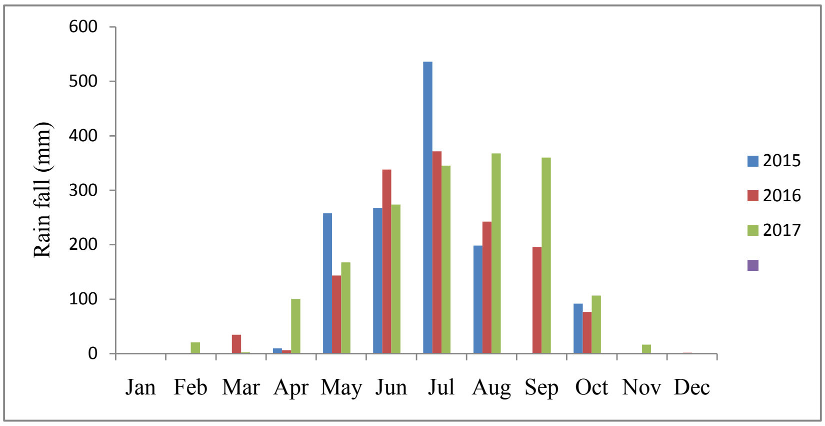

Figure 1: Monthly total rain falls for 2016. 2017 and 2018 crop growing seasons and the 30 year average rainfall at Kamashi Zone, and around the trial farm.

of return (MRR) was calculated. The % MRR between any pair of undominated treatments denotes the return per unit of investment in fertilizer expressed as a percentage.

RESULTS AND DISCUSSION

Soil Physico-chemical Properties before Sowing

Nitisols is the major soil types found in all *Weredas* of Kamashi zone. This might be occurred due to in high rainfall areas on flat to slopping terrains. It is dark reddish brown to dark red in color with deeply developed clay alleviation horizon of high structural stability. Nitisols are well drained, porous with high water holding capacity. The texture of these soils is clay-to-clay loam with moderate organic matter content and relatively easily weathering minerals. The soil used for the study ranges from moderate acidic (pH 5.46) to the slightly acidic (pH 5.71) class indicating the possibility of Al toxicity and deficiency of certain plant nutrients. The exchangeable K of the soil before the application of the treatments ranges from 0.46 cmol (+) kg^{1} to 0.51 cmol (+)kg^{1}. All experimental soils had adequate K content. Available (Bray II extractable) soil P level of less than 5 ppm is rated as low,6-10 ppm as medium, 11-25 high and greater than 25 mg kg^{1} is rated as very high. Thus, both trial year had low to medium (bray II extractable) P (Table 1). Following the rating of total N of >1% as very high, 0.5 to 1% high, 0.2 to 0.5% medium, 0.1 to 0.2% low and <0.1% as very low N status as indicated by Landon [10], the experimental soils qualify for low total N. Similarly, the organic carbon (OC) content of the soil was also very low to low in accordance with Landon [10], who categorized OCcontent as very low (<2%), low (2-4%), medium (4-10%), high (10-20%). The very low OC and low N content in the study area indicate low fertility status of the soil. This could be due to continuous cultivation and lack of incorporation of organic materials (Table 1).

Influence of year, N&P on yield of sesame

Year had highly significant (P<0.01) influence on seed yield of sesame. The significant (P<0.001) effect of year on seed yield showed that sesame had higher seed yield in 2017 (932.24kgha^{-1}) than in 2014 (369.19kg ha^{-1})(Table 2). Comparing the seed yield of sesame, the higher seed yield(932.24kgha^{-1}) improved by 152.5% during to 2016 as compared to during 2014. The analysis variance of two factorial randomized complete block design indicated that the interaction effect of N & P kg ha^{-1}had significant (p<0.05) effect on seed yield of sesame (Table 2.). However the main effect of N & P had non-significant (p>0.05) effects on seed yield of sesame. The higher mean yield (998.9kg ha^{-1}) was obtained from 46N & 10Pkg ha^{-1}interaction however the lower mean yield was recorded from the control. Comparing the seed yield of sesame the application of 46N and 10P kg ha^{-1}had improved the seed yield of sesame by 248.0% compared to the control plants.

Partial budget analysis

The application of **46 N and10P** kg ha^{-1} had the highest net-benefit of **29,502.8**ETB, followed by 69 N &10P kg, 46 N &20 P kg $ha^{-1}$and 23 N &10P kg ha^{-1} which also had a total of 22,217.3, 20,997.4and 20,234.7ETB net benefit respectively. The lowest net benefit was obtained by the application of the control with total of 9,184ETB followed by 0N & 20 P kg ha $^{-1}$with net benefit of 12,301.2ETB. The increased production of the crop due to the application of inputs might or might not be beneficiary to farmers [9]. Therefore, partial budget analysis [9] was employed to estimate the net benefit,dominance analysis and marginal rate of return that could be obtained from various alternative treatments [9].The profitability of the study showed that application of **46 N and10P** kg ha^{-1} which provided the relatively high net benefit (**29,502.8**ETB,), was the peak to apply fertilizers (Table 3).

Marginal rate of return

The highest net benefits from the application of inputs for the production of the crop might not be sufficient for the farmers to accept as good practices. In most cases, farmers prefer the highest profit (with low cost and high income). For this purpose it is necessary to conduct dominated treatment analysis [9]. The % MRR between any pair of undominated treatments denotes the return

Table 1: Chemical analysis of some parameters of soil prior to cropping.

Year	depth	PH	%OC	%N	ppmP	Meq.K/100g	Meq.CEC/100g
2016	0-20cm	5.71	1.476	0.11	10.8	0.51	22.6
2018	0-20cm	5.46	1.870	0.17	9.8	0.46	23.2

Table 2: Means for main effect of year and interaction N & P fertilizer rates on sesame yield.

Factor	Grain yield(kg ha^{-1})		
Year			
2016	369.19		
2018	932.24		
Sig. level	***		
LSD(0.05)	69.94		
		P rates (kg ha^{-1})	
N rates(kgha^{-1})	0	10	20
0	287^{d}	420^{cd}	451.6^{cd}
23	478^{bcd}	687.6^{abc}	638.5^{ab}
46	634.3^{abc}	998.9^{a}	766.7^{ab}
69	682.9^{abc}	792.9^{ab}	804.5^{ab}
Mean	520.48	699.71	665.33
Duncan (0.05)		236.9	
CV (%)		22.6	

Table 3: Partial Budget Analysis of N and P rate on sesame at Kamashi location.

Fertilizer rates (N &p	Total variable cost	Total income	Net benefit	Marginal increase in net benefit	Marginal increase in variable cost(Birr ha^{-1})	MRR (%)	Dominance
Control(0,0)	0	9184	9184	-	-	-	
0,10	1075	13440	12365	3181	1075	296	
0,20	2150	14451.2	12301.2	3117.2	2150	D	D
23,0	693.5	17097.6	14602.5	5418.5	693.5	781	3rd
23,10	1768.5	22003.2	20234.7	11050.7	1768.5	625	
23,20	2843.5	24912	17588.5	8404.5	1075	782	2nd
46,0	1387	20297.6	18910.6	9726.6	1387	701	
46,10	**2462**	**27804.8**	**29502.8**	**20318.8**	**2462**	**825**	**1st**
46,20	3537	24534.4	20997.4	11813.4	3537	D	D
69,0	2080.5	21852.8	19772.3	10588.3	2080.5	509	
69,10	3155.5	25372.8	22217.3	13033.3	3155.5	413	

per unit of investment in fertilizer expressed as a percentage.A dominated treatment is any treatment that has net benefits that are less than those of a treatment with lower costs that vary.

Economic analysis revealed that maximum marginal rate of return was recorded with application of **46 N and10**Pkg ha^{-1} **(825%)**, followed by 23N &20P kg ha^{-1}(782%) and 23N kg ha^{-1}(781%) respectively. The marginal rates of those treatments were well above the 100% minimum [9]. .According to CIMMYT [9] experience and empirical evidence, for the majority of situations indicated that the minimum rate of return acceptable to farmers would be between 50 and 100%. In the present study the treatments that had above 100% marginal ratereturn was recommended for the farmers, with treatments that had small number of variable cost.

The % MRR between any pair of undominated treatments denotes the return per unit of investment in fertilizer expressed as a percentage. The results of undominated treatments indicated that for each one birr invested in purchase or production of fertilizers that was possible to recover one birr plus an extra of 8.25 birr ha^{-1} ,7.82 birr ha^{-1} and 7.81 ha^{-1}as the fertilizer application changed from unfertilized plot to **46 N and10**P kg ha^{-1}, 23N &20P kg ha^{-1}and 23N kg ha^{-1}respectively. Passing from the first treatment that had the lowest costs that vary to the end treatment which had the highest cost that vary, the marginal rate of return obtained was above the minimum acceptable marginal rate of return. In this study, 100% was considered as minimum acceptable rate of return for farmers" recommendation. Accordingly, the study revealed that application of **46 N and10** P kg ha^{-1}was considered as the best for recommendation. The best recommendation for treatments subjected to marginal rate of return is not necessarily based on the highest marginal rate of return, rather based on the minimum acceptable marginal rate of return and the treatment with the highest net benefit, relatively low variable cost together with an acceptable MRR becomes the tentative recommendation [9].

SUMMARY AND CONCLUSION

The experimental soil was moderatelyto slightly acidic in pH, very low organic carbon, low in total nitrogen, below the critical level of available P (Bray II).The higher mean yield (998.9kg ha^{-1}) was obtained from 46 N & 10Pkg ha^{-1} interaction, and the lower mean yield was recorded from the control. Comparing the seed yield of sesame the application of 46N & 10P kg ha^{-1} had improved the seed yield of sesame by 248.0% compared to the control plants.

The profitability of the study showed that application of **46 N and10P**kg ha^{-1}which provided the relatively highest net benefit **(29,502.8**ETB), was the peak to apply fertilizers. The results of undominated treatments indicated that for each one birr invested in purchase or production of fertilizers that was possible to recover one birr plus an extra of 8.25 birr ha^{-1}, 7.82 birr ha^{-1} and 7.81 as the fertilizer application changed from unfertilized plot to **46 N and10**P kg ha^{-1}, 23N &20P kg ha^{-1}and 23N kg ha^{-1}respectively. The best recommendation for treatments subjected to marginal rate of return is not necessarily based on the highest marginal rate of return, rather based on the minimum acceptable marginal rate of return and the treatment with the high net benefit, relatively low variable cost together with an acceptable MRR becomes the tentative recommendation. Therefore we recommend the treatments (**46 N and 10**Pkg ha^{-1}) that have acceptable marginal rate of return, relatively high net benefit and relatively small total cost of production for Sesame production in Kamashi zone.

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