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Effect of NPS and N Fertilizer Rates on Growth and Yield of Sesame (*Sesamum indicum* L.) at Western Oromiya, Ethiopia

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Abstract: The experiment was carried out for three year (2019, 2020 and 2021) in the districts of Bako, Uke, and Chawaka with the aim of to determine optimum NPS and nitrogen fertilizers for sesame cultivation. Five level of NPS (0, 25, 50, 75, and 100 kg ha^{-1}) and four level of Nitrogen (0, 23, 6 and 69 kg ha^{-1}) were used in the experiment. RCBD with three replicates in factorial arrangement was used. The findings indicate that NPS and nitrogen fertilizers had a significant impact on the primary branch, capsules per plant, and yield. Applying of 100 kg NPS x 23 N kg ha^{-1} and 100 kg NPS x 46 kg ha^{-1} N fertilizers produced the maximum grain yields (10.19 quintals and 10.36 quintals ha^{-1}) respectively. Low grain yield (6.89 quintals ha^{-1}) was obtained from 0 kg NPS x 0 kg ha^{-1} N fertilizers. A partial budget analysis revealed that the highest net benefit (3130ETB) and marginal rate of return (1330%) obtained from 100 kg NPS x 23 kg N per hectare. Therefore for the production of sesame in the study area, it was advised to utilize fertilizer at a rate of 100 kg NPS ha^{-1} + 23 kg N ha^{-1}.

Keywords: Fertilizer, Marginal Rate of Return, Net Benefit, Sesame, Yield

1. Introduction

The annual crop known as sesame (Sesamum indicum L.) is one of the world's oldest oilseeds, farmed especially for its high oil content. The seeds have a protein level of 25% and an oil content of 52–57%. [1]. Because of its superior quality, it is known as the "Queen of Oilseeds." According to the research [2] the United Republic of Tanzania, India, China, Sudan, Nigeria, Myanmar, Burkina Faso, and Ethiopia are the top sesame producers, accounting for 70.88% of global production. Along with Nigeria and Egypt, Ethiopia is the primary producer of sesame in Africa [3].

Ethiopia's valuable export crop is sesame. It produced at the elevation is less than 2000 meters above sea level [4]. Sesame oil and seed are used for a wide range of purposes in Ethiopia. In addition to being used for cooking, oil is also used to anoint bodies. The calcium-rich oil cake is utilized as animal feed. The seed is used to prepare a variety of meals [4]. According to Central statistical Agency of Ethiopia [5] in 2020 growing season, Ethiopia's sesame yield and production area were 2,678,665.46 quintals and 337,926.82 hectares, respectively.

The most prevalent and commonly utilized inorganic fertilizer in many crops is nitrogen. Nitrogen in readily usable forms is obtained by plants from a variety of sources. Numerous studies have documented the beneficial benefits of nitrogen fertilizer on development, crop traits, seed output, and sesame quality. According to the research [6], adding 40 kg of nitrogen per hectare greatly increased sesame yield and yield components. According to research [7], applying 60 kg of nitrogen per hectare resulted in the highest possible sesame output.

Enough soil phosphorus encourages accelerated plant development, early fruiting or ripening, and frequently enhances plant quality [8]. According to the research [9], adding P_2O_5 at a rate of 30 kg/ha considerably increase plant height, branch number and capsules per plant, the weight of 1,000 seeds and the amount of seed and oil produced per hectare. Sesame growth and production were greatly boosted by the adding of P_2O_5 at rates of 40 kg/ha [10], 45 kg/ha [11], and 60 kg/ha [12]. An essential plant nutrient called sulfur can have a substantial effect on the productivity and yield of oilseeds. It is well recognized for its part in the production of proteins, oils, and vitamins, but it also has significant influence on the quality and growth of oilseeds.

The solely nitrogen and phosphorus-containing urea and diammonium phosphate (DAP) used in Ethiopian agriculture. They are unlikely to satisfy the dietary requirements of crops, nevertheless. A new compound fertilizer (NPS) has just been launched by the nation's Ministry of Agriculture to replace DAP in Ethiopian agriculture in order to prevent this issue.

Therefore this experiment was done with the objective of;

1) To identify the best fertilizer application rate for sesame cultivation using NPS and nitrogen.
2) To examine the interaction effect between the application of nitrogen and NPS fertilizer on sesame growth and yield.

2. Material and Methodes

2.1. Study Area

The experiment was carried out at Bako, Chewaka and Uke site for three cropping season (2019, 2021 and 2022). Bako is found between 9^0 06' 10.98 N to 37^0 02' 30.714'' E and its altitude 1658m, Chewaka site is found between 8^0 59' 42.816 N to 36^0 07' 58.415''E and its altitude 1241m and uke site located 9^0 25' 04.86''N to 36^0 32'21.76''E its altitude 1324m.

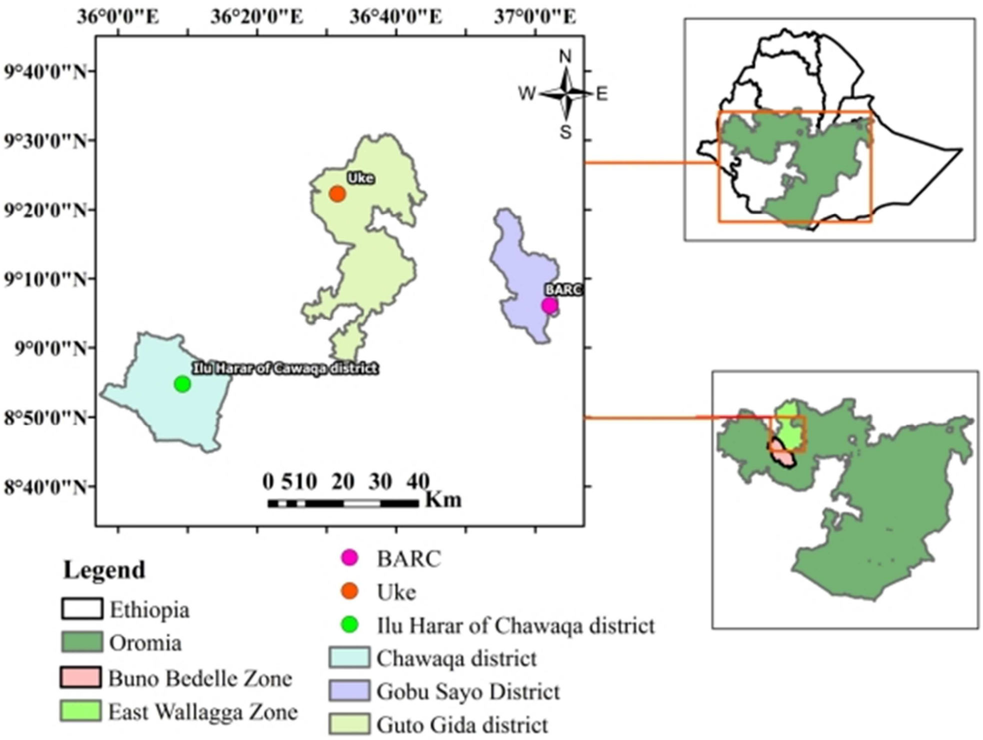

Figure 1. *Map of the study area.*

2.2. Treatments and Design

Five level of NPS (0, 25, 50, 75, and 100 kg ha^{-1}) and four level of (0, 23, 46 and 69 kg ha^{-1}) were used in the experiment. RCBD with three replicates in factorial arrangement was used. One sesame variety (Obsa) was used as test crop. Plot area 3m long and 2.4m width, The space between row and plant was 40 cm and 10cm respectively.

2.3. Experimental Procedures

Before planting, the plot had been well-prepared NPS fertilizer was added to the row in accordance with the treatment and mixed with the soil only at planting and nitrogen fertilizer was split in to two applications 50% during planting and the remaining 50% during the crop's vegetative stage. The seeds were sowed in the experimental area at a seed rate of 5 kg/ha. Composite soil samples were taken from each location prior to planting in order to determine the physico-chemical properties of the soil.

2.4. Data Collection

Crop Phenology and growth: flowering date, maturity date, Plant height and Number of primary branches.

Yield and yield components: Number of capsule per plant and yield.

Quality parameters: Oil content (%).

2.5. Statistical Data Analysis

Analysis of Variance was performed statically using the general linear model of ANOVA and SAS software. The least significant difference (lsd) test was used to calculate the mean separation at the 5%cofidental level.

3. Results and Discussion

Table 1. Experimental soil's physico-chemical characteristics before planting.

Soil characteristic	Value			
	Bako	Uke	Chawaka	Description
pH (1:2.5 H2O)	5.04	5.36	5.66	Acidic
Organic matter (%)	1.56	1.83	1.9	Low
Total nitrogen (%)	0.14	0.31	0.39	Poor
Available phosphorous (ppm)	9.85	6.71	7.03	low

3.1. Crop Phenology and Growth

Flowering and physiological maturity date were not affected by NPS and N fertilizer rates, but they were affected by location. Maturity period at Bako site was 131.84 days long, however it took an average of 110.08 days in the Chawka and Uke locations to achieve maturity (Table 2). It's possible that the difference results from variations in temperature and altitude. At lower temperatures and higher altitudes, crop phenology expanded. The effects of rising temperatures have a greater effect on yield than on vegetative development. This impacts lead to an increase in maturity, which lowers the crop's capacity to efficiently fill grain. The days to flowering and physiological maturity also varied significantly between sites, according to (Thomas George *et al.*) When compared to the lowest elevations, both phenological processes were markedly delayed at higher elevations. [13].

Table 2. Effects of NPS and N fertilizer on days to flowering and physiological maturity.

Treatment	Bako		Chawaka and Uke	
	DF	DM	DF	DM
Nitrogen fertilizer				
0	71.73	131.97	70.13	110.80
23	71.63	132.03	69.57	110.73
46	72.03	131.37	69.63	110.47
69	71.33	132.00	69.57	110.33
LSD	NS		NS	NS
NPS fertilizer				
0	72.29	132.17	71.33	111.17
25	71.75	132.08	70.58	110.42
50	72.08	131.50	69.58	110.83
75	71.70	131.58	68.29	110.42
100	71.33	131.58	68.83	110.08
LSD (0.05)	NS	NS	NS	NS
Mean	71.83	131.84	69.72	110.58
CV (%)	1.53	1.24	2.17	1.28

DF= Days to Flowering; DM= Days to physiological maturity; LSD = Least Significant (P< 0.05); CV = Coefficient of Variation; NS =Non Significant

3.2. Plant Height

Plant height was significantly affected by the main effect of N and NPS fertilizer rates (P<0.01) but not by interactions. Following fertilizer applications of 69 kg N ha^{-1} and 100 kg NPS ha^{-1}, the maximum plant height was measured to be 107.00 cm and 110.26 cm, respectively (Table 3). The plant's height increased as the fertilizer application increased from zero to highest fertilizer.

Plant height grew when nitrogen fertilizer application increased from 0 kg to 200 kg [14] which is consistent with this finding. Similar to the current findings, plant height responded favorably to high N fertilizer application [15], and the author [16] also noted a strong relationship between plant height and N concentrations ranging from 0 to 22.4 and 44.8 kg/ha. The main effects of N fertilizer and NPS fertilizer rates have a significant effect on primary branch per plant.

Table 3. Effects of NPS and N fertilizer rates on plant height and primary branch.

Treatment	PH (cm)	PBPP
Nitrogen		
0	92.61d	7.19b
23	96.43c	7.38b
46	102.03b	7.68a
69	107.00a	7.76a
LSD	2.35	0.24
NPS		
0	89.84e	6.62e
25	93.41d	7.00d
50	100.08c	7.43c
75	104.00b	8.08b
100	110.26a	8.37a
LSD (0.05)	2.63	0.27
CV (%)	6.57	9.01

PH= plant height; PBPP= primary branch per plant; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation; NS =Non Significant

3.3. Capsule Per Plant

Capsules produced per plant were significantly impacted by the main effects of NPS and N fertilizer rates as well as their interaction. As the amount of NPS increased from 0 to 100 kg, the amount of capsules produced by each plant increased. However, the observed difference in capsules per plant was minimal, with nitrogen fertilizer rates increased from zero to 69 kg ha^{-1}. Adding of 100 kg NPS ha^{-1} + 46 kg N ha^{-1} and 100 kg NPS ha^{-1} + 69 kg N ha^{-1} produced the maximum capsules per plant (67.83 and 67.25), respectively. No application of fertilizer produced the low capsules per plant (Table 4). With increased fertilizer rates, plants may have access to fertilizers more frequently than no fertilizer application which could explain why there are more capsules per plant.

Table 4. *Interaction effect of NPS and N fertilizer rates on Sesame Capsule per plant.*

NPS	N			
	0kg 1	23kg 2	46kg 3	69kg 4
0kg 1	35.17j	44.50i	48.5hi	48.17hi
25kg 2	49.17h	48.00hi	51.17gh	53.83fg
50kg 3	54.83fg	54.42fg	57.17ef	57.50d-e
75kg 4	57.83d-f	59.83c-e	61.83b-d	64.50ab
100kg 5	65.83ab	64.17a-c	67.83a	67.25.16a
LSD (0.05) 4.60				
CV (%) 10.29				

3.4. Grain Yield (kg ha^{-1})

The major effects of NPS and nitrogen fertilizers and their interaction had a highly significant effect on grain yield. When 100 kg NPS ha^{-1} + 23 kg N ha^{-1} and 100 kg NPS ha^{-1} 46 kg Nha^{-1} were used, the maximum grain yields of 10.19 quintals and 10.36 quintals ha^{-1} were attained. The control treatment (0 kg NPS ha^{-1} 0 kg N ha^{-1}) had the lowest grain yield (6.89 quintals ha^{-1}) measured (Table 5). Since N fertilizer rates range from 0 kg ha^{-1} to 69 kg ha^{-1}, the yield difference observed was minimal even though increasing NPS fertilizer from 0 kg ha^{-1} to 100 kg ha^{-1} considerably boosted production. This can be as a result of the fact that an excessive amount of N treatment decreases fruit and yield while promoting plant growth [17]. The average yield of sesame was greatly boosted by using NPK fertilizer up to 150 kg/ha [18].

Table 5. *Interaction effect of NPS and nitrogen fertilizer rates on grain yield (quintals ha^{-1}).*

NPS	Nitrogen			
	0kg	23kg	46kg	69kg
0kg	6.89i	7.02i	7.05i	7.15i
25kg	7.39g-i	7.32h-i	7.99f-h	8.02e-h
50kg	8.09e-g	8.12ef	7.89f-h	8.45ef
75kg	8.32ef	8.72de	9.29cd	9.52bc
100kg	8.58df	10.19ab	10.36a	9.59bc
LSD (0.05) 0.73				
CV (%) 10.96				

3.5. Economic Evaluation

According to CIMMYT [19] partial budget analysis was used to create the economic forecasts. The average amount of sesame obtained from each treatment is used as the basis for the economic analysis. As a result, Table 6 displays the estimated net benefit for each of the 20 treatments. The treatment of 100 kg NPS ha^{-1} + 23 kg N ha^{-1} gave the greatest net benefit (3130 ETB). The lowest net benefit (31005 ETB) obtained from (0 kg NPS ha^{-1} 0 kg N ha^{-1}).

Table 6. *Partial budget analysis of NPS and nitrogen fertilizers on sesame.*

Treatments (NPS x N)	Average Yield kg ha^{-1}	Adjusted yield (10%) kg ha^{-1}	Cost of NPS (ETB) ha^{-1}	Cost of N ha^{-1}	Cost of labor for fertilizer Application (ETB) ha^{-1}	TVC (ETB)	sesame Price (ETB)\kg $^{-1}$	Gross return (ETB) kg $^{-1}$	Net benefit (ETB) kg $^{-1}$	
0kg x 0kg	689	620.1	0	0	0	0	50	31005	31005	
25kg x 0kg	739	665.1	387.5	0	75	462.5	50	33255	32792.5	
50kg x 0kg	809	728.1	575	0	150	725	50	36405	35680	
0kg x 23kg	702	631.8	0	725	150	875	50	31590	30715	D
25kg x 23kg	732	658.8	387.5	725	225	1337.5	50	32940	31602.5	D
75kg x 0kg	832	748.8	1162.5	0	225	1387.5	50	37440	36052.5	
0kg x 46kg	705	634.5	0	1450	300	1750	50	31725	29975	D
50kg x 23kg	812	730.8	775	725	300	1800	50	36540	34740	D
100kg x 0kg	858	772.2	1550	0	300	1850	50	38610	36760	
25kg x 46kg	799	719.1	387.5	1450	375	2212.5	50	35955	33742.5	D
75kg x 23kg	872	784.8	1162.5	725	375	2262.5	50	39240	36977.5	
0kg x 69kg	715	643.5	0	2175	450	2625	50	32175	29550	D
50kg x 46kg	789	710.1	775	1450	450	2675	50	35505	32830	D
100kg x 23kg	1019	917.1	1550	725	450	2725	50	45855	43130	
25kg x 69kg	802	721.8	387.5	2175	525	3087.5	50	36090	33002.5	D
75kg x 46kg	929	836.1	1162.5	1450	525	3137.5	50	41805	38667.5	D
50kg x 69kg	845	760.5	775	2175	600	3550	50	38025	34475	D
100kg x 46kg	1036	932.4	1550	1450	600	3600	50	46620	43020	D
75kg x 69kg	952	856.8	1162.5	2175	675	4012.5	50	42840	38827.5	D
100kg x 69kg	959	863.1	1550	2175	750	4475	50	43155	38680	D

ETB= Ethiopian birr, D= Dominated

3.6. Marginal Rate of Return

As indicated (Table 7), the highest MRR (1330%) was recorded from the treatment of 100 kg NPS ha^{-1} + 23 kg N ha^{-1} fertilizer applied.

According to the analysis of dominating treatments, as fertilizer application increased from zero to 100 kg NPS and 23 kg N ha^{-1}, it was possible to return each one birr invested plus an additional 3.86, 11.00, 0.56, 1.52, 0.52, and 13.30 birr ha^{-1}. Therefore 100 kg NPS ha^{-1} and 23 kg N ha^{-1} were the best for sesame production in the study area and corresponding agroecology.

Table 7. *Marginal rate of return of NPS and N fertilizers application on sesame.*

Treatments	TVC	MC	NB	MB	MRR
(NPS x N)	0				
0kg +0kg			31005		
25kg +0kg	462.5	462.5	32792.5	1787.5	386
50khg +0kg	725	262.5	35680	2887.5	1100
75kg +0kg	1387.5	662.5	36052.5	372.5	56
100kg + 0kg	1850	462.5	36760	707.5	152
75kg + 23kg	2262.5	412.5	36977.5	217.5	52
100kg +23kg	2725	462.5	43130	6152.5	1330

TVC = Total variable cost; MC= marginal cost, NB=net benefit MB= marginal benefit, MRR= marginal ret of return, ETB= Ethiopian birr

4. Conclusion and Recommendation

Low yield of sesame are mostly caused by poor agronomic practice, lack of improved variety and soil acidity in western oromia, Ethiopia. To improve the income, way of life, and health of farmers, these situations ought to be changed.

According to the findings, N fertilizer had a smaller impact on yield and capsules per plant than NPS fertilizer. The Capsule per plant and yield improved significantly when NPS fertilizer was raised from 0 kg ha^{-1} to 100 kg ha^{-1}, but when N fertilizer rates range from 0 kg to 69 kg ha^{-1}, the observed difference was small.

Adding of 100 kg NPS ha $^{-1}$ + 46 kg N and 100 kg NPS ha $^{-1}$ + 23 N kg ha^{-1}, produced the highest yield (10.36 quintals ha $^{-1}$ and 10.19 quintals ha -1, respectively. The control treatment (0 kg NPS ha^{-1} + 0 kg N ha^{-1}) had the lowest grain yield (6.89 quintals kg $ha^{-1)}$. However, the application of 100 kg NPS ha $^{-1}$ + 23 kg N ha $^{-1}$ produced the largest net benefit (43130ETB) and marginal rate of return (1330%). As a result, it was advised to use fertilizer rates of 100 kg NPS + 23 kg N ha^{-1} for the production of sesame in the study area.

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