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Effect of Different Blended Fertilizers Formulae for the Productivity of Sesame at Bench Maji Zone, South Ethiopia

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Abstract

Sesame productivity in our country Ethiopia is low due to unbalanced fertilization and soil fertility degradation beyond disease and lacking using an improved variety of sesame. The experiment was conducted for two growing seasons to identify the effects of different blended fertilizer formulae applications on sesame yield and yield components at Menit Goldia. The treatments are control, nitrogen, phosphorus, sulfur and boron (NPSB) formula 1 = 46 kg.ha^{-1} N, 54 kg.ha^{-1} P,10 kg.ha^{-1} S, and 1.07 kg.ha^{-1} B; formulae 2 = 69 kg.ha^{-1} N,72 kg.ha^{-1} P,13 kg.ha^{-1} S, and 1.4 kg.ha^{-1} B, formula 3 = 92 kg.ha^{-1} N, 90 kg.ha^{-1} P, 17 kg.ha^{-1} S, and 1.7 kg.ha^{-1} B. The experiment was arranged in a randomized complete block design with three replications. The application NPSB formula resulted in the highest sesame yield and yield component as compared to the control. The economic analysis demonstrated that the maximum net benefit with the highest marginal rate of return was obtained due to the application of formula 3 as compared to control, therefore formula 3 is recommended to grow sesame at Menit Goldia and other areas with similar environment.

Keywords: grain yield, inorganic fertilizer, soil fertility,

Introduction

Sesame (*Sesamum indicum* L.) is a very important cash oil seed crop; in Ethiopia, both small-scale farmers and investors share more than 300,000 hectares of land in sesame production every year and more than 90% of the yield is exported (Yaregal, 2022). Sesame seeds are the second major source of foreign exchange in Ethiopia (Girmay, 2018). Sesame productivity in Ethiopia is low due to different limiting factors (CSA, 2021), among others, caused by unbalanced fertilization and soil fertility degradation, plant diseases, and the lack of improved varieties of sesame. In addition, sesame is one of the heavy feeder crops, i.e., requires high supply of nutrients to produce maximum-quality oil seeds (Golla et al., 2019). Therefore, supplying blended fertilizers is essential to increase sesame productivity and quality (Deci and Ryan, 2018). The continuous addition of N (nitrogen) and P (phosphorus) fertilizers was reported to decrease the amount of other nutrients in the soil solution including boron (B) and sulfur (S) (ATA, 2016). Therefore, providing S and B fertilizers might increase the output of crops (CSA, 2022); this could be realized by applying blended fertilizers containing N, P, S, B, and extra vital plant nutrients. The addition of plant nutrient fertilizers corresponding to prior soil fertility situations makes indications of the economic use of fertilizers (Eifediyi et al., 2016).

Plant nutrient deficiency due to imbalanced fertilizer use is a common problem in the Ethiopia (Geserto and Adare, 2022). Previous reports indicated that plant nutrients like Sulphur and Boron are becoming exhausted and their deficiency symptoms are occurring in different crops across different areas of Ethiopia (Sertsu and Bekele, 2000). Soil result data from EthioSIS (Ethiopian Soil Information System) also indicated that beyond N and P, plant nutrients such as S, and B, are inadequate in Ethiopian soils. In addition, EthioSIS also revealed that soils of the Menit Goldia district are low sulfur, boron, nitrogen, and phosphorus. This indicated continuous use of blanket recommended N and P decreases sesame productivity by aggravating S and B deficiency that are highly taken up in the crop (Zebene and Geleta, 2022).

Lacks in suitable fertilizers that are supplied with micronutrients is a common national problem that contributes to constraints for sesame and other crops' productivity improvement in agricultural land. To increase the productivity of sesame in cultivated agricultural land application of blended fertilizer formula that contain boron, sulfur, and other micro-nutrients is important rather than sole blanket recommendation N and P from urea and DAP (CSA, 2022). Hence, the current study was intended to

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identify the best fertilizer formula to increase sesame production at Menit Goldia Woreda, Bench-Maji Zone, Ethiopia.

Material and Methods

Description of Study Area

The study was done at Menit Goldia districts in Bench Maji Zone for two years (2016-2018) main cropping season. Bench-Maji Zone is situated in the Southern Nations, Nationalities, and People Regional State (SNNPR) in the southwestern part of Ethiopia, about 560 km in the southwest direction of Addis Ababa. Geographically, Menit Goldia is positioned at 60^0 52” N latitude and 35.50^0 21” E longitude with an altitude extending from 1050 to 1300 meters above sea level. The mean annual rainfall and temperature in the area is 1500 mm and 27°C, respectively. The study area has varied physio-geographic landscapes with high and rugged mountains, level-topped plateaus, deep gorges, engraved river valleys, and rolling plains.

Experimental Design

The trial was set in a randomized complete block design with the following treatments: control, nitrogen, phosphorus, sulfur and boron (NPSB) formula 1 = 46 $kg.ha^{-1}$ N, 54 $kg.ha^{-1}$ P,10 $kg.ha^{-1}$ S, and 1.07 $kg.ha^{-1}$ B; formula 2 = 69 $kg.ha^{-1}$ N, 72 $kg.ha^{-1}$ P, 13 $kg.ha^{-1}$ S, and 1.4 $kg.ha^{-1}$ B, and formula 3 = 92 $kg.ha^{-1}$ N, 90 $kg.ha^{-1}$ P, 17 $kg.ha^{-1}$ S, and 1.7 $kg.ha^{-1}$ B. The source of fertilizers was urea for N, triple superphosphate (TSP) for P, calcium sulphate ($CaSO_4$) for S, and Borax for B. For this trial, the sesame variety “Abasena” was used as a test crop because this variety is recently released variety by Worer Agricultural Research Center due to their high yields and less shattering problems. Sesame seeds were sown manually at the recommended seeds level of 2 $kg.ha^{-1}$ with 40 cm distance between rows, 0.5 m between plots (16 m^2), and 1m between blocks.

Data was collected from the middle eight rows of each plot. Nitrogen was applied in two splits, the first at sowing and secondly at 21 days after sowing within rows. Phosphorus, sulfur and boron was applied as basal in rows at planting.

Data Collection

Physical (bulk density and texture) and chemical pH (hydrogen concentration), OC (organic carbon), TN (total nitrogen), av-K (available potassium), av-P (available phosphorus), and CEC (cation exchange capacity) soil properties were taken before planting for laboratory analysis. Determination of particle size distribution was done using the hydrometer method by Sahlemedhin and Taye (2000); percentage of sand, silt, and clay were calculated and identified using FAO textural triangle. Bulk density was determined using the cylindrical core sampling method indicated in Sahlemedhin and Taye (2000). Soil pH was measured in water at a ratio of 1:2.5 using a glass electrode pH meter. The soil organic matter was determined following the wet digestion method as outlined by Walkley and Black which involves the digestion of the organic matter in the soil samples with potassium dichromate ($K_2Cr_2O_7$) in sulfuric acid solution. Av-P was determined by (Olsen et al., 1954) extracting method. The total N content in the soil samples was determined following the Kjeldahl method. CEC was determined by extracting the soil samples with ammonium acetate (1N NH_4OAc) followed by repeated washing with ethanol (96%) to remove the excess ammonium ions in the soil solution. Analysis of available potassium was done by extracting Morgan solution at pH 4.8 and determined by flame photometer. The available sulfur (av-S) and available boron (av-B) were determined by the micronutrient analysis manual of Houba et al. (1989).

Soil test analysis (Table 1) revealed that the soil has clay texture class with the pH value of 5.7 in 1:2.5 soil-to-water ratio, so it is moderately acidic. Soil total N was 0.58%, so it is classified as high based on Tadese (1991). Soil available P according to Olsen et al. (1954) is low, CEC is classified as high based on Hazelton (2007), whereas available boron and sulfur were medium (Jones, 2003).

Agronomic Data

Plant height, pod length, number of branches per plant, number of capsules per plant, above-ground biomass, total pod yield, and harvesting index were measured.

Table 1. Soil physico-chemical properties before planting

Bulk density ($g.cm^{-3}$)	Particle size (%)			Texture	pH	TN%	Av-P (ppm)	Av-S ($mg.kg^{-1}$)	Av-B ($mg.kg^{-1}$)	CEC ($cmol(+).kg^{-1}$)
	Sand	Silt	Clay							
1.29	21	27	52	Clay	5.7	0.58	4.67	10	0.35	27.5

Notes: pH= hydrogen concentration, TN=total nitrogen, Av-P= available phosphorus, av-S= available sulfur, av-B= available boron, CEC = cation exchange capacity.

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The harvest index was calculated based on Donald and Hamblin (1976) formula:

$$\mathrm{HI} = \frac{\mathrm{GY}}{\mathrm{AGB}} * 100$$

where
HI=harvest index,
GY=grain yield
AGB= above ground biomass

Data Analysis

Data were analyzed using analysis of variance analyzed through the SAS software program version 9.4 (SAS Institute, 2002). Least significant test (LSD) at 0.05 probability level was engaged to isolated treatments means where significant differences exist (Gomez and Gomez, 1984).

Economic Analysis

Economic analysis was used to examine the economic feasibility of the treatments. The dominance analysis procedure as detailed in (CIMMYT, 1988) was used to select potentially profitable treatments from the range that was tested. The chosen and rejected treatments using this technique are denoted as undominated and dominated treatments, respectively. The undominated treatments were ranked from the lowest (the farmers' practice) to the highest cost.

Result and Discussion

Grain Yield, Fresh Above-Ground Biomass, and Number of Capsules Per Plant

Yield and yield components of sesame are affected at (P< 0.05) by the application of different blended fertilizer formula (Table 2). The application of blended fertilizer formula 3 resulted in the highest above-ground biomass and grain yield of sesame whereas the lowest above-ground grain yield was obtained from untreated treatment (Table 2).

The result from this study is similar to the findings of Chimdessa (2016) who reported that the supplement of blended fertilizers (N, P, Cu, Zn) gave a higher grain yield of maize as compared to the control. In addition, Chimdessa (2016) indicated that the lowermost value of the above-ground biomass yield of maize was achieved from control while the uppermost values were obtained in plots that received blended fertilizers.

The number of capsules per plant was significantly increased (p<0.05) by the application of different blended fertilizer formulae (Table 2). The application of blended fertilizer formula 3 resulted in the maximum number of capsules per plant whereas the minimum values of capsules per plant were observed from the control treatment. The finding is lined with the study by Utama and Dabalo (2017) in the Eastern Harerghe Zone where the application of 40 kg.ha^{-1} nitrogen and 10 kg.ha^{-1} P_2O_5 had the maximum (68.67) number of capsules per plant as compared to the lowest value (48.21) which comes from the control. The study conducted by Girma (2019) also indicated that the number of capsules per plant increased from 19.78 to 29.37 by increasing nitrogen application from 0 to 75 kg.ha^{-1}.

Partial Budget Analysis

The economic analysis was performed to make rational choice among the applied variables in the production of sesame. The net benefit and marginal

Table 2. Effects of blended fertilizer formulae on sesame yield parameters.

Treatment	Plant height (cm)	Number of branches per plant	Number of capsules per plant	Above-ground biomass (kg.ha^{-1})	Grain yield (kg.ha^{1})	Harvest index (%)
Control	157.90	2.87^{b}	41.87±5.1^{b}	2768.3±100^{c}	430.9±50^{c}	15.57
Formula 1	162.13	3.67^{ab}	57.93±4.6^{ab}	3675±119^{bc}	666.1±98^{b}	18.13
Formula 2	153.03	4.10^{a}	60.60±9.8^{a}	4468±245^{ab}	689.3±45^{b}	15.43
Formula 3	164.40	3.93^{a}	74.60±10.4^{a}	5778±256^{a}	963.7±84^{a}	16.8
LSD (0.05%)	ns	ns	17.39	1828.3	220.95	ns
CV (%)	7.36	19.88	24.15	35.03	25.95	14.95

Notes: Values followed by the same letter (s) within the column are not significantly different at (p ≤0.05 according to the least significant different test (LSD); ns = not-significant. CV= coefficient of variations. Formula 1= nitrogen, phosphorus, sulfur and boron (NPSB) formula 1 = 46 kg.ha^{-1} N, 54 kg.ha^{-1} P,10 kg.ha^{-1} S, and 1.07 kg.ha^{-1} B; Formula 2 = 69 kg.ha^{-1} N, 72 kg.ha^{-1} P,13 kg.ha^{-1} S, and 1.4 kg.ha^{-1} B; Formula 3 = 92 kg.ha^{-1} N,90 kg.ha^{-1} P, 17 kg.ha^{-1} S, and 1.7 kg.ha^{-1} B.

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Table 3. Partial budget analysis of blended fertilizers on sesame at Menit Goldia, Bench Maji zone.

Treatments	Actual yield ($kg.ha^{-1}$)	Adjusted grain yield ($kg.ha^{-1}$)	Total growth benefit (Birr)	Total variable cost (Birr)	Net benefit (Birr)	Marginal rate of return
Control	430.9	387.81	5817.15	0	5817.15	-
Formula 1	666.1	599.49	8992.35	2513.69	6478.66	26.3
Formula 2	689.3	620.37	9305.55	3476.48	5829.07	-
Formula 3	963.7	867.33	13009.95	4429.18	8580.77	109.7

Notes: Formula 1= nitrogen, phosphorus, sulfur and boron (NPSB) formula 1 = 46 $kg.ha^{-1}$ N, 54 $kg.ha^{-1}$ P,10 $kg.ha^{-1}$ S, and 1.07 $kg.ha^{-1}$ B; Formula 2 = 69 $kg.ha^{-1}$ N,72 $kg.ha^{-1}$ P, 13 $kg.ha^{-1}$ S, and 1.4 $kg.ha^{-1}$ B; Formula 3 = 92 $kg.ha^{-1}$ N, 90 $kg.ha^{-1}$ P, 17 $kg.ha^{-1}$ S, and 1.7 $kg.ha^{-1}$ B.

rate of return (MRR) were used for evaluating the change in farming methods that affect partially rather than the whole farm practice and also concerned with planning tool to estimate the profit change within a farm (CIMMYT, 1988). The analysis was computed by adjusting yield downward by a 10% and multiplying it with the local field price (60 Ethiopian Birr per kg of sesame seeds). Dominance analysis was done by listing of treatments in an increasing order of cost and that has net benefit less than or equal to treatments with the lower costs that vary is dominated (CIMMYT, 1988).

The economic analysis emphasizes that most treatments with a marginal rate of return give a higher net benefit than the control (Table 3). The application of F3 gave the maximum net benefit with a marginal rate of return of 10970%. This is indicative that for every 1.00 Birr invested for the F3 field, farmers can gain an extra 109.7 Birr (CIMMYT, 1988). The maximum net benefit of 8580.77 $Birr.ha^{-1}$ was attained from the treatment of F3 (Table 3) while the minimum net benefit of 5817.15 $Birr.ha^{-1}$ was gained from the control (Table 3). Therefore, the most economical rate for producers with low cost and the higher benefit was treatment F3.

Conclusion

Application of different fertilizer formulas increased the sesame above-ground biomass, grain yield, and the number of capsules per plant compared to the control, therefore application of fertilizers especially in blended form is very important to improve sesame productivity. Fertilizer formula 3, i.e., 92 $kg.ha^{-1}$ N,90 $kg.ha^{-1}$ P,17 $kg.ha^{-1}$ S, and 1.7 $kg.ha^{-1}$ B, gave the best yield than other two fertilizer formula, therefore this treatment is recommended for sesame growers to maximize their yield. Further studies will be conducted to achieve a sustainable sesame production system by including organic matter amendment in combination with inorganic fertilizer and blending formulas.

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