International Journal of Scientific Research Updates

Journal homepage: https://orionjournals.com/ijsru/

ISSN: 2783-0160 (Online)

ORION SCHOLAR JOURNALS

(RESEARCH ARTICLE)

Blended NPSB fertilizer rates effect on growth, yield and yield components of sesame (*Sesamum indicum* L.) varieties at konso, Southern Ethiopia

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International Journal of Scientific Research Updates, 2022, 03(02), 050–063

Publication history: Received on 05 April 2022; revised on 06 May 2022; accepted on 08 May 2022

Article DOI: https://doi.org/10.53430/ijsru.2022.3.2.0036

Abstract

Sesame is an important cash and food oil crop cultivated in low lands of Ethiopia. However, sesame productivity was constrained due to declining soil fertility, inadequate extension and demonstration of improved high yielding varieties. Thus, response of sesame varieties to rates of blended NPSB fertilizer was studied at Konso, Southern Ethiopia, during 2019/2020 cropping season to determine sesame varieties and blended NPSB fertilizer rate on growth, yield, and yield components. The experiment consisted of three sesame varieties and five blended NPSB fertilizer rates laid out in Randomized Complete Block Design with three replications. Results of analysis showed that days to crop phenology, growth, seed yield and oil content variables were significantly ($p<0.05$) affected due to sesame varieties and blended NPSB fertilizer rates. Variety Setit-2 showed maximum plant height (153.83cm), number of nods plant^{-1} (31), number of branches plant^{-1} (8), number of capsules plant^{-1} (129), number of seeds capsule^{-1} (67) and 1000 seed weight (3.52g). Maximum number of days to 50% flowering (54), days to physiological maturity (93), plant height (146.17cm) and oil content (58.51%) were recorded at 200 kg ha^{-1} blended NPSB fertilizer. High nods plant^{-1} (32), number of branches plant^{-1} (8), number of capsules plant^{-1} (141), number of seeds capsule^{-1} (68) and thousand seed weight (3.87g) were recorded at 100 kg ha^{-1} blended NPSB fertilizer. The highest above ground dry biomass (4298.96 kg ha^{-1}), harvest index (25.6%), seed yield (1099.33 kg ha^{-1}) and oil yield (616.16 kg ha^{-1}) recorded from variety Setit-2 when combined with 100kg ha^{-1}blended NPSB fertilizer. Thus, blended fertilizer at rate of 100kg NPSB ha^{-1} and Setit-2 were suggested for sesame production the study area.

Keywords: Blended Fertilizer; Oil Content; Soil Fertility; Varieties

1 Introduction

Sesame (*Sesamum indicum* L.) is one of the oldest widely grown and most important cultivated oil crops in tropical and subtropical regions around the world [1] with in 2012, the world sesame seed production was 4,441,620 tons and in Africa, average productivity ranges from 300 to 500kg ha^{-1} in pure stand; but under good management it reaches as high as 3000kg ha^{-1} [2]. The crop is produced in different areas in Ethiopia, mainly at Northern, Eastern, and Southern, [3] with production of 255,903.43 tons. The productivity of sesame varieties in Ethiopia is very low when compared with other countries [4]. Constraints of sesame production in Ethiopia are weeds, insect pests, diseases, drought, low productive sesame varieties, traditional farming, shattering, less attention to sesame research when compared to other crops [4]. Lack of improved varieties, poor extension and demonstration of existing cultivars is also among the limiting factors for sesame production [3]. Soil erosion, deforestation, continuous cultivation of the same land, inadequate applications of organic and inorganic fertilizers and decreasing or abandoning of useful traditional soil restoration practices are some of the causes of declining soil fertility [5].

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Sesame is next to coffee in terms of foreign exchange earnings and as a main source of income for over three million Ethiopians [6]. It has high potential in the world market for high quality seed varieties that are suitable for a wide range of applications [7]. The growing demand of sesame in the world market and the capacity to expand sesame production contributed for economic growth of Ethiopia [8, 9]. It accounted over 90% of the values of oil seeds exports from Ethiopia to the world [8]. The good and encouraging oil qualities of sesame varieties currently under production indicated for further improvement [10]. The suitability of environmental condition for sesame crop production and the presence of genetically diverse sesame germplasm in Ethiopia gave better potential for improvement and wider adaptation.

Lack of blended fertilizer with appropriate micronutrients is a national problem constituting a major constraint to crop productivity [11]. 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 Di ammonium phosphate (DAP), especially those that contain potassium, sulphur and other micro nutrients [12]. Therefore, soil test based fertilizer recommendations could be designed for reducing such production constraints. Nutrient mining due to suboptimal fertilizer use on one hand and unbalanced fertilizer uses on the other hand have favored the emergence of multi nutrient deficiencies in Ethiopian soil. The Ministry of Agriculture of Ethiopia has recently introduced a new compound fertilizer (NPSB) containing nitrogen, phosphorous, sulphur and boron with the ratio of 19% N, 38% P_2O_5, 7% S and 0.1% B. This fertilizer has currently substituted DAP in Ethiopian crop production system as the main source of phosphorous [12]. Moreover, the effect of blended NPSB fertilizer recommended to substitute DAP in the region has not been studied for seed yield and seed quality of sesame varieties.

2 Material and methods

2.1 Description of the Study Area

The field experiment was conducted on farmer field at Konso Zone, Southern, Ethiopia under rain fed conditions during the 2019/2020 cropping season (summer). The experimental site is located at a latitude of 5°45′96″ N and longitude of 37°44′93″ E at an altitude of 1171 m.a.s.l. The experimental area is characterized with bimodal rainfall distribution pattern classed under lowland agro ecological Zone, mean annual minimum and maximum temperature of 27^{o}c and 32^{o}c, respectively [13] and soil texture of clay loam.

2.2 Treatments and experimental design

The field experiment consisted of three sesame cultivars (Setit-1, Setit-2 and Gonder-1) and five rates of blended NPSB fertilizer (0, 50, 100,150 and 200 kg ha^{-1}). The treatments were laid out as factorial arrangement in randomized complete block design (RCBD) with three replications. Each treatment was assigned randomly to the respective experimental units within a block. The experimental plots consisted 6 rows spaced at 0.4 m and 0.1 m between plants where 4 of the central rows was used for data collection. Each varieties seed drilled over well ploughed and manually levelled plots at rate of 5 kg ha^{-1} along the rows of depth 0.25 m. The extra plants were thinned at 0.1 m spacing 10 days after plant emergence when the seedlings attain 15cm (at pencil size height). The amount of blended NPSB fertilizer rate for each plot was drilled along the row during planting.

Data on days to 50% flowering, days to physiological maturity, plant height, number of nods $plant^{-1}$, number of branches $plant^{-1}$, number of capsules $plant^{-1}$, number of seeds $capsule^{-1}$, thousand seed weight, above ground dry biomass, harvest index, seed yield, oil content and oil yield was recorded. The collected data was subjected to analysis of variance (ANOVA) using Statistical Application Systems (SAS) software version 9 [15]. Significant difference among the means was separated using Least Significant Difference (LSD) at 5% probability level.

3 Results and discussion

3.1 Days to 50% flowering (DF)

Results of days to 50% flowering of sesame varieties as affected by blended NPSB fertilizer rates is presented in Table 1. The result showed that number of days to 50% flowering was significantly ($P<0.05$) affected by blended NPSB fertilizer application rates and varieties. The interaction between blended NPSB fertilizer rates and sesame varieties was not significant.

Among the three sesame varieties, Setit-2 (43.7 days) and Setit-1 (46.8 days) flowered early when compared with Gondar-1 (63.3 days) (Table 1) indicating genetic difference of flowering among varieties. The observed variation in days to 50% flowering is in line with [16], who reported days to 50% flowering differences among sesame varieties attributed to genetic makeup of the crop and growing environment. Significance difference in 50% flowering among varieties was also documented by [17].

Maximum number of days (54) to reach 50% flowering was recorded at 200 kg ha^{-1} blended NPSB fertilizer rate, while the earliest days to 50% flowering (48.1) was recorded from no fertilizer applied (control) plot. The result showed that day to 50% flowering delayed with increasing rates of blended NPSB fertilizer rates (Table 1). The result indicated contribution of each blended NPSB nutrient as sources of vegetative growth for the crop. The addition of nitrogen and phosphorus in blended fertilizer contributed to the availability of soil nutrients for plant growth whereby the nitrogen fertilization delayed days to flowering. The variation in days to 50% flowering is also the contribution of stimulatory effect of phosphorus element on growth hormones which induced late flowering in sesame varieties. This result was in line with the findings of [18] who reported increased days to 50% flowering with increasing levels of nitrogen application.

3.2 Days to maturity (DM)

The result of analysis of days to maturity of sesame varieties as affected by blended NPSB fertilizer rates indicated that days to maturity was significantly (P<0.05) affected due to blended NPSB fertilizer application rates and sesame varieties. The interaction between blended NPSB fertilizer rates and sesame varieties was not significant (Table 1).

According to the result, sesame variety Setit-2 required short days (83.4 days) to attain physiological maturity after planting when compared with the other two varieties. Phenological characteristics are genetically controlled where individual varieties expressed different growing habit, flowering and maturity days. The observed variation in days to maturity was similar with findings of [19] who reported difference in days to maturity among sesame varieties mainly contributed to genetic makeup of the crop.

Table 1 Days to 50% flowering and maturity as affected by blended NPSB fertilizer rates and sesame varieties at Konso during 2020 cropping season

Treatments	DF (days)	DM (days)
Varieties		
Setit-1	46.8^{b}	86.53^{b}
Setit-2	43.66^{c}	83.4^{c}
Gonder-1	63.33^{a}	97.2^{a}
LSD (0.05)	1.67	1.85
NPSB fertilizer rates (kg ha^{-1})		
0	48.1^{d}	85.8^{d}
50	49.77^{cd}	87.4^{dc}
100	51.66^{cb}	88.6^{bc}
150	52.44^{ab}	90.3^{b}
200	54.00^{a}	92.88^{a}
Grand Mean	51.26	89.04
LSD (0.05)	2.39	2.15
CV (%)	4.29	2.72
Variety*NPSB Fertilizer Rates	Ns	Ns

Where mean values followed by different letters indicates significance difference at P<0.05; NS= no significant difference.

Maximum number of days to maturity (92.88) was recorded at blended NPSB fertilizer rate of 200 kg ha^{-1}, while the minimum days to maturity (85.8) was recorded from no fertilizer applied (control) plot suggesting delay of maturity due to increasing fertilizer application. Crops extend their duration to maturity when the growing environment shows less stress in nutrients. The delay in days to maturity at maximum blended NPSB fertilizer rate could be nitrogen nutrition in blended fertilizer which increases the vegetative growth of plants. This result was in line with findings of [20] who reported that increased nitrogen application rate from 0 to 46 kg N ha^{-1} led to a significant increase in the number of days required to reach physiological maturity. This variation in days to maturity also be attributing by genotypic differences of the respective varieties and their response to rates of blended NPSB fertilizer application.

3.3 Plant height (cm)

The result demonstrated that plant height was significantly ($p<0.05$) affected due to blended NPSB fertilizer application rates and sesame varieties. The interaction between blended fertilizer and sesame varieties was not significant (Table 2).

According to the result, sesame variety setit-2 showed significantly high plant height (153.83 cm) when compared to Setit-1 (136.56 cm) and Gonder-1 (133.73 cm) (Table 2) suggesting genetic differences among varieties. The observed variation in plant height is in line with [21, 22] who reported plant height differences among sesame varieties mainly attributed to genetic makeup of the crop and growing environment.

The maximum plant height (146.17 cm) also recorded when applying blended NPSB fertilizer rate at 200 kg ha^{-1} which was statistically similar with plant height at 150 kg ha^{-1} and 100 kg ha^{-1} blended NPSB fertilizer rate. The minimum plant height (133.53 cm) was recorded from plot with no fertilizer applied (control). The result showed increased plant height with increasing rates of blended NPSB fertilizer rate, indicating combined role of N, P, S and B nutrition and the crop response towards nutrients in demand for growth and development. The crop growth response also suggests significant contribution of N and P nutrition on plant height. Phosphorus functions in the formation of more roots thereby enhancing the uptake of more nutrients including N as documented by [24]. This result was similar with [23], who reported maximum plant height (167.47 cm) record with blended NPSZnB fertilizer rate application at Humara station. Application of boron @ 10 kg ha^{-1} increased the plant height due to role of boron in cell elongation, photosynthesis and transpiration as documented by [25]. Similarly, [26] also reported that increase in plant height due to interaction of sulphur with nitrogen enhanced the vegetative growth of the plant.

3.4 Number of branches per plant (NBPP)

Table 2 Plant height and Number of branches per plant as affected by sesame varieties and blended NPSB fertilizer rates at Konso during 2020 cropping season, Southern Ethiopia

Treatments	**PH (cm)**	**NBPP**
Varieties		
Setit-1	136.56^{b}	6.34^{b}
Setit-2	153.83^{a}	8.06^{a}
Gondar-1	133.73^{c}	5.96^{c}
LSD (0.05)	2.7	0.35
NPSB Rates (kg ha^{-1})		
0	133.53^{c}	5.62^{d}
50	137.57^{b}	6.15^{c}
100	144.33^{a}	8.06^{a}
150	145.24^{a}	7.17^{b}
200	146.17^{a}	6.9^{b}
Grand Mean	141.39	6.79
LSD (0.05)	3.58	0.46
CV (%)	2.54	6.99
Variety*NPSB fertilizer rates	Ns	Ns

Note: LSD (0.05) = Least Significant Difference at 5% level; CV (%) = Coefficient of variation; Mean values followed by the same letters are not significantly different at P<0.05 level of significance and different letters indicates significance difference at P<0.05; NS= no significant difference at 5% level.

The result of the analysis of number of branches per plant of sesame varieties as affected by blended fertilizer rates showed that number of branches per plant was significantly ($p<0.05$) affected by blended NPSB fertilizer application rates and varieties. The interaction between blended fertilizer rate and sesame varieties was not significant (Table 2).

The result indicated that maximum (8.06) number of branches per plant was recorded for sesame variety Setit-2, and the minimum (5.96) was obtained from sesame variety Gonder-1 suggesting the existence of genetic difference among sesame varieties in number of branch production (Table 2). The observed variation in number of branches per plant was in line with the findings of [21], who reported that number of branches per plant varied among sesame varieties. Significance difference in branches per plant among varieties was also documented by [22].

The highest number of branches per plant was recorded from blended NPSB fertilizer rate at 100 kg ha^{-1}, while lowest number of branch per plant (5.62) was recorded from control plot. The result indicated the contribution of mineral nutrition for more number of branch production. Individual mineral nutrients in blended fertilizer enabled more crop growth and resulted in improved branches $plant^{-1}$. Sulphur enhances the metabolic and meristematic activities of crop resulting in optimum growth, plant height and branches $plant^{-1}$ of sesame [27]. This result was in line with the findings of [24], who reported that number of branches increased linearly with increased rates of nitrogen. The author reported that application of 112.5 kg ha^{-1} nitrogen gave significantly high number of branches when compared with nitrogen at 37.5 and 0 kg ha^{-1} rate on sesame. Numbers of branches $plant^{-1}$ also increased with increasing sulphur levels and higher branches $plant^{-1}$ was recorded in plots applied with 40 kg ha^{-1} sulphur as documented by [28]. Different levels of nitrogen and phosphorus significantly ($P<0.05$) affected sesame varieties. Maximum number of branches $plant^{-1}$ of sesame was recorded in NP @ 70:70 kg ha^{-1}, followed by NP @ 70:50 kg ha^{-1}, whereas minimum growth and yield parameters were noted in no fertilizer (Control) as documented by [29]. Number of branch per plant increased from 14.33 to 18.33 as the application of DAP and UREA fertilizer increased from 0 kg (control) to 24.6 kg [30]. Significance difference among number of branches $plant^{-1}$ was recorded in blended NPS fertilizer rate at 50kg ha^{-1}, followed by 100 kg ha^{-1}, whereas minimum number of branches was noted in no fertilizer (Control) applied plot [31]. The results suggested the significance of balanced mineral nutrition for crop growth and development.

3.5 Number of capsules per plant (NCPP)

Table 3 Number of nods and number of capsules per plant as affected by sesame varieties and blended NPSB fertilizer rates at Konso during 2020 cropping season.

Treatments	**NNPP**	**NCPP**
Varieties		
Setit-1	28.32^{b}	121.38^{b}
Setit-2	31.32^{a}	128.99^{a}
Gondar-1	27.23^{b}	111.17^{c}
LSD (0.05)	2.16	6.19
NPSB Rates (kg ha^{-1})		
0	24.75^{c}	91.49^{d}
50	27.55^{b}	107.09^{c}
100	32.4^{a}	141.06^{a}
150	29.66^{ab}	135.55^{a}
200	30.4^{ab}	127.37^{b}
Grand Mean	28.95	120.51
LSD (0.05)	2.79	7.5
CV (%)	6.56	6.43
Variety*NPSB fertilizer rates	Ns	Ns

Where mean values followed by the same letters are not significantly different at $P<0.05$ level of significance; Ns= no significant difference at 5% level.

The result showed that number of capsules plant^{-1} of sesame was significantly ($p<0.05$) affected by blended NPSB fertilizer application rates and sesame varieties. However, their interaction was not significant (Table 3).

The result showed that sesame variety Setit-2 showed maximum number of capsule per plant (128.99) when compared to number of capsules produced in Gonder-1 (111.21) and setit^{-1} (121.2) (Table 3). The difference in number of capsule per plant production suggested the existing genetic difference between the sesame varieties and variety by environmental interaction. The observed variation in number of capsules per plant was similar with the findings of [22, 32, 21] who reported significant differences in capsule number among sesame varieties.

The highest number of capsules per plant (141.06) was recorded from blended NPSB fertilizer rate at 100 kg ha^{-1}, and the lowest number (91.49) recorded from control plot (Table 3). The result indicated increasing number of capsule production from increasing blended NPSB fertilizer application suggestion increasing crop growth response towards integrated nutrition for improved crop growth and productivity. Application of 100kg ha^{-1} significantly enhanced number of capsules per plant by 47.4% when compared with control. The increasing number of capsules production plant^{-1} was also noted with increasing nitrogen and DAP application rate where high number of capsules plant^{-1} (48.6) was recorded from nitrogen at 105 kg ha^{-1} and phosphorus at 92 kg ha^{-1} while the lowest number of capsules plant^{-1} was recorded on non-fertilized plants [33]. The nitrogen application rate (75 kg ha^{-1}) resulted in high number of capsules indicated the crop nutrient needs in which other nutrients contributed their share for highest number of capsules plant^{-1} as reported by [24]. The result was also in line with [27] who indicated maximum number of capsules plant^{-1} (196.1) from sulphur applied at 30 kg ha^{-1}, while low number of capsules plant^{-1} (138) from no fertilizer applied plot. Capsules plant^{-1} linearly increased with increasing sulphur levels and high number of capsules plants^{-1} observed in plots fertilized with 40 kg ha^{-1} sulphur as compared to control plots of sesame also reported by [28].

The difference in number of capsules production among varieties due to Boron application and season by variety interaction was documented by [34]. Significant effect of blended fertilizer nutrition on capsule production also noted with Boron and Sulphur nutrition. Increase in number of capsules plant^{-1} with application of Boron and Sulphur nutrient application reported by [25].

3.6 Number of nods per plant (NNPP)

As presented in Table 3, number of nods per plant was significantly ($p<0.05$) affected by blended NPSB fertilizer application rates and sesame varieties. The interaction between blended fertilizer and sesame varieties was not significant. The result indicated that sesame variety Setit-2 recorded high (31.32) number of nods per plant than Setit-1 (28.32) and Gonder-1 (27.23). The result suggested difference among the sesame varieties in number of nod production. The observed variation in number of nods per plant is in line with findings of [35], who reported variation in number of nods per plant. Significance difference in number of nods per plant among sesame varieties was documented by [36].

Maximum number of nods per plant (32.4) was recorded from blended NPSB fertilizer at 100 kg ha^{-1}, while the minimum number (24.8) was recorded from no fertilizer applied (control) plot. The difference in number of nods per plant indicated favor of integrated nutrient application as sources for vegetative growth and crop need. This result was in line with [33], who also reported different number of nodes per sesame crop in application of nitrogen and phosphorus fertilizer.

3.7 Number of seeds per capsule (NSPC)

The results of the analysis showed that number of seeds per capsules was significantly ($p<0.05$) affected due to blended NPSB fertilizer application rates and sesame varieties. The interaction between blended fertilizer and sesame varieties was not significant (Table 4).

The number of seeds per capsule ranged from 58 to 67 where the highest number of seeds per capsules recorded from sesame variety Setit-2 while the minimum was recorded from variety Gonder-1 (Table 4). The result indicated the genetic difference in production of seeds per capsule among the varieties and the growing environment. The observed variation in number of seeds per capsule is in line with findings of [19, 17], who reported high number of seed capsule^{-1} from Setit-2 variety followed by Setit-1. Significance difference in number of seeds per capsule among sesame varieties was also documented by [17].

Maximum number of seeds per capsule (68.46) was recorded from blended NPSB fertilizer rate at 100 kg ha^{-1}, which was statistically on par with 150 kg ha^{-1} and the lowest number of seeds per capsules (58.51) was recorded from control plot (Table 4). The result showed increment in number of seeds production per capsule with increasing blended NPSB nutrient application rate suggesting contribution essential nutrients in seed formation. This result was in line with findings of [29], who reported the contribution of phosphorus as key plant structural compounds and stimulating root development, stem strength, flower development and seed formation and enhancing crop maturity. Contribution of blended nutrition also recognized in blended NPS fertilizer application where number of seeds production per capsule increased with increasing blended NPS fertilizer application from control (no fertilizer applied plot) to 100 Kg ha^{-1} [31].

Table 4 Yield and yield related components as affected by sesame varieties and blended NPSB fertilizer rates at Konso during 2020 cropping season, Southern Ethiopia

Treatments	**NSPC**	**TSW (g)**	**AGDB (kg ha^{-1})**	**SY (kg ha^{-1})**	**HI (%)**
Varieties					
Setit-1	63.12^{b}	3.48^{ab}	3395.91^{b}	731.44^{b}	21.45^{b}
Setit-2	67.01^{a}	3.57^{a}	3810.49^{a}	828.46^{a}	21.67^{b}
Gondar-1	58.32^{c}	3.29^{b}	2905.95^{c}	674.99^{c}	23.03^{a}
LSD (0.05)	2.10	0.20	86.80	30.52	1.16
NPSB rate (kg ha^{-1})					
0	58.51^{d}	3.06^{c}	2863.6^{d}	564.54^{c}	19.66^{c}
50	60.78^{dc}	3.38^{b}	3175.21^{c}	696.06^{c}	22.00^{b}
100	68.46^{a}	3.87^{a}	3735.74^{a}	937.33^{a}	25.07^{a}
150	63.68^{a}	3.45^{b}	3595.38^{b}	779.01^{b}	21.88^{b}
200	62.63^{bc}	3.46^{b}	3483.98^{b}	747.89^{b}	21.66^{b}
Grand Mean	62.82	3.45	3370.8	744.96	22.05
LSD (0.05)	2.72	0.08	112.10	39.39	1.50
CV (%)	3.64	8.48	3.26	5.50	7.30
Variety*NPSB Fertilizer Rates	Ns	Ns	*	*	*

Note: Ns = Non- significant at 5% level of error; Mean values followed by the same letters are not significantly different at P<0.05 level

3.8 Thousand seeds weight (g) (TSW)

As presented in Table 4 thousand seed weight was significantly ($p<0.05$) affected due to blended NPSB fertilizer application rates and sesame varieties. But the interaction between the two factors was not significant. The thousand seed weight ranged from 3.29 g to 3.57g where the maximum recorded from variety Setit-2 and the minimum from variety Setit[1]. The result suggested genetic difference among varieties in response to applied nutrient and environmental conditions. The observed variation in thousand seed weight is in line with the findings of [36, 19], who reported significant differences in thousand seed weight among sesame varieties.

Maximum thousand seed weight (3.87 g) was recorded from blended NPSB fertilizer rate at 100 kg ha^{-1} while minimum (3.06 g) was recorded from control plot (Table 4). The increasing rate of blended NPSB fertilizer application increased thousand seed weight, indicated nutrient enhanced efficiency for crop growth. The result was in line with findings of [37], who reported of combined NP fertilizers at 60:30 kg ha^{-1} produced the highest thousand seed weight (3.83g). A significant variation in thousand seed weights of sesame as a result of sulphur and boron application was also documented by [25]. A balanced nutrition is quite essential for crop growth and development. Significantly increased hundred seed weight due to increased interaction between N and P fertilizer application was also reported by [40]. Maximum thousand seed weight (4.21 g) was observed when 50 kg ha^{-1} sulphur was applied and minimum thousand seed weight (3.3 g) was obtained with no sulphur applied plot was reported by [26]. The increase in thousand seed weight might be due to role of sulphur in activating the growth and yield components.

3.9 Above ground dry biomass (kg ha^{-1}) (AGDB)

As presented in Table 4, above ground dry biomass was significantly ($p<0.05$) affected due to blended NPSB fertilizer application rates and sesame varieties. The interaction between blended NPSB application rates and varieties was also found significant ($p<0.05$). The result showed that sesame variety Setit-2 when combined with 100 kg ha^{-1} blended NPSB fertilizer rate produced significantly high above ground dry biomass (4298.96 kg ha^{-1}) while significantly low above ground dry biomass (2398.83 kg ha^{-1}) recorded when variety Gonder-1 combined with control plot (Table 5). The result indicated difference in response to sesame varieties when applying varying integrated nutrition rates. The result also suggested the superiority of sesame variety Setit-2 in dry matter production towards integrated nutrient application when compared with Gonder-1. The result showed the contribution of growth and yield components response towards combined nutrient application in biomass production. The N, P, S and B nutrition increased the number of branches per plant and leaf area which in turn increased photosynthetic area and number of capsules per plant thereby dry matter accumulation. This result was in line with findings of [24], who reported significant contribution of blended NPK fertilizer application on above ground dry biomass, and favor nutritional balance in the growth and development of the crops.

Table 5 Interaction effects of varieties and NPSB rate on above ground dry biomass of sesame at Konso 2020

	NPSB (kg ha^{-1})				
Variety	**0**	**50**	**100**	**150**	**200**
Setit-1	3035.2^{f}	3240.3^{e}	3670.3^{c}	3573.53^{cd}	3460.13^{d}
Setit-2	3156.66^{ef}	3489.66^{cd}	4298.96^{a}	4097.73^{b}	4009.4^{b}
Gonder-1	2398.93^{h}	2795.66^{g}	3237.9^{e}	3114.86^{ef}	2982.4^{f}
Grand mean	3370.8				
CV (%)	3.4				

Note: CV (%) = Coefficient of variation; Mean values followed by the same letters are not significantly different at 5% level of significance and different letters indicates significance difference at ($P<0.05$).

[28], also reported contribution of N and S as principal constituent of proteins, enzymes, hormones and chlorophyll which contribute to improved leaf area index and increased above ground dry biomass. Similar finding on above ground dry biomass on sesame crop was reported by [26].

3.10 Seed yield (kg ha^{-1}) (SY)

The results of analysis of variance of seed yield of sesame varieties as affected by blended NPSB fertilizer rate showed that seed yield was significantly ($p<0.05$) affected by blended NPSB fertilizer application rates and sesame varieties. Similarly, the interaction between blended NPSB fertilizer application rates and sesame varieties was significant ($p<0.05$) (Table 4). Maximum seed yield of 1099.33kg ha^{-1} was recorded when sesame variety Setit-2 applied with 100 kg ha^{-1} blended NPSB fertilizer rate while minimum seed yield (448.48 kg ha^{-1}) was noted when sesame variety Gonder-1 combined with no fertilizer applied (control) plot. The result indicated productive response of Setit-2 towards integrated nutrient application and the nutrient demand (Table 6). The variation in seed yield among the varieties might be attributed to their genetic potential and the contribution of individual nutrients in blended fertilizers.

The observed variation in seed yield is in line with [24], who reported significant interaction of NPK on seed yield and dry matter due to nutritional balance that favors the functioning of each nutrient in the growth and development of crops. The increment in yield might be due to stimulatory effect of sulphur in NPSB fertilizer on protein synthesis, cell division, cell elongation, setting of cell structure and might have involved in the improvement of yield related traits of the sesame crop leading to higher seed yield [28]. The application sulphur improves soil structure and it increases the usefulness of other plant nutrients which in turn increases sesame yield [38].

Boron application enhanced carbohydrate transport within the plant, photosynthetic activity and metabolic activity [39]. Phosphorus plays a fundamental role in metabolism and energy producing reaction and can withstand the adverse environmental effects whereas nitrogen affects the vegetative as well as yields, thus resulting in enhanced grain yield [29]. Nitrogen and phosphorus (N:P) applied @ 100:80 kg ha^{-1} showed better growth and yield of sesame [40]. Largest seed yield ha^{-1} was recorded when both nitrogen and phosphorus were applied at the highest rate (128 kg ha^{-1} N and 92 kg ha^{-1} P) whereas the smallest seed yield was obtained from unfertilized plots [33]. Plants applied with 100 kg ha^{-1}

blended NPS fertilizer produced 34% additional increment over the control [31]. The highest grain yield of sesame was obtained from the application of 150 kg ha^{-1} blended NPSZnB fertilizer at Humera station [23].

The increase in seed yield with blended NPSB fertilizer application might be related with the results of number of branches, number of capsules per plant, number of seeds per capsules and thousand seeds weight. This result was similar with [41, 42], who reported that number of branches, number of capsules per plant, number of seeds per capsule and thousand seeds weight are most determinant and crucial traits in identifying high yielding sesame varieties.

Table 6 Seed yield of sesame as affected by interaction sesame varieties and NPSB fertilizer rate at Konso during 2020 cropping season

NPSB (kg ha^{-1})					
Variety	**0**	**50**	**100**	**150**	**200**
Setit-1	581.90^{h}	718.15^{ef}	905.50^{b}	731.80^{e}	719.80^{ef}
Setit-2	662.83^{fg}	728.48^{ef}	1099.33^{a}	840.29^{bc}	811.36^{cd}
Gonder-1	448.84^{i}	641.54^{gh}	807.16^{cd}	764.92^{de}	712.48^{ef}
Grand mean	744.96				
CV (%)	5.49				

3.11 Harvest Index (%) (HI)

Result of the analysis of variance to harvest index of sesame varieties showed that harvest index was significantly ($p<0.05$) affected by blended NPSB fertilizer application rates and sesame varieties. The interaction between blended NPSB application rates and sesame varieties were also significant ($p<0.05$) (Table 4).

The highest harvest index (25.6%) was obtained when variety Setit-2 combined with 100kg ha^{-1} blended NPSB fertilizer rate while the lowest (18.79%) was recorded when variety Gonder-1 combined with no NPSB fertilizer applied plots (Table 7). Harvest index is essential indicator of increase in economic yield due to increasing nutrition. The result suggested the contribution of increasing integrated nutrition application in maximizing crop growth, development and yield.

Table 7 Interaction effects of varieties and NPSB rate on harvest index of sesame at Konso 2020

NPSB (kg ha^{-1})					
Variety	**0**	**50**	**100**	**150**	**200**
Setit-1	19.18^{d}	22.15^{bc}	24.66^{ab}	20.47^{cd}	20.81^{cd}
Setit-2	21^{cd}	20.87^{cd}	25.6^{a}	20.6^{cd}	20.29^{cd}
Gonder-1	18.79^{d}	22.97^{abc}	24.93^{a}	24.57^{ab}	23.89^{ab}
Grand mean	22				
CV (%)	7.3				

Note: Mean values followed by the same letters are not significantly different at 5% level of significance and different letters indicates significance difference at ($P<0.05$).

The highest harvest index record was the indicator of high economic yield than the dry biomass [37], suggesting synergistic effect of integrated nutrients. This result is in agreement with the findings of [37] who reported highest harvest index (48.37%) and the lowest harvest index (30.25%) from the integrated NP fertilizer application, 60:30 NP kg ha^{-1} and 90:45 NP kg ha^{-1}, respectively. Interaction between nitrogen and phosphorous showed that optimum harvest index (12.90 %) from combined NP application rate of 60:80 kg ha^{-1} as reported by [40].

3.12 Oil Content (%) (OC)

Result of the analysis of variance to oil content of sesame varieties as affected by blended fertilizer rates is presented in Table 8. The result showed that oil content was significantly ($p<0.05$) affected due to blended NPSB fertilizer application rates and sesame varieties. The interaction between blended NPSB application rates and sesame varieties was not significant.

Table 8 Oil content and oil yield as affected by sesame varieties and blended NPSB fertilizer rates at Konso during 2020 cropping season

Treatments	**OC (%)**	**OY(kg ha^{-1})**
Varieties		
Setit-1	56.84^{a}	417.01^{b}
Setit-2	54.74^{b}	456.66^{a}
Gondar-1	52.79^{c}	358.51^{c}
LSD (0.05)	1.49	18.27
NPSB Rates (kg ha^{-1})		
0	49.67^{d}	279.96^{d}
50	53.97^{c}	376.47^{c}
100	55.21^{cd}	518.75^{a}
150	56.60^{ab}	440.75^{b}
200	58.51^{a}	437.7^{b}
Grand Mean	54.79	410.73
LSD (0.05)	1.9	23.58
CV (%)	3.63	5.85
Variety*NPSB Fertilizer Rates	NS	*

Note: Mean values followed by the same letters are not significantly different at 5% level of significance; Ns= no significant difference at 5% level.

The seed oil content ranged from 52.79% to 56.84% where the result where maximum oil content recorded from variety Setit-1 followed by Setit-2 (54.74%) and minimum was recorded from Gonder-1 (Table 8). The result suggested that variation in sesame oil content due to interaction of genotypes to different environmental condition and genetic difference among sesame varieties. The observed variation in oil content is similar with the findings of [43], who reported significant differences in oil content among sesame varieties at different areas. Significance difference in oil content among sesame varieties was also documented by [44].

Maximum percentage of oil content (58.51%) was recorded at 200kg ha^{-1} blended NPSB fertilizer rate while the lowest percentage of oil content (49.67) was recorded from control plot (Table 8). Oil content was favored by fertilizer application as [29] reported and also influenced significantly by NP application where maximum (48%) attained at 50:50 of kg ha^{-1} NP application level

The increment in percentage of oil content with increasing NPSB fertilizer application rates could be associated with sulphur nutrition in blended fertilizer which enhances oil synthesis. Sulphur plays a crucial role in the synthesis of proteins, in formation of chlorophyll in plant leaf, amino acids methionine and cysteine and drought tolerance ability in plant [45, 46]. This result was in line with findings of [47, 48], who reported the highest oil content (43.97%) was obtained in 30 kg ha^{-1} Sulphur and lowest oil content (32.80%) was obtained in control treatment.

3.13 Oil yield (kg ha^{-1})

As presented in Table 8, result of the analysis of variance of oil yield of sesame varieties was significantly ($p<0.05$) affected by blended NPSB fertilizer application rates and sesame varieties. The interaction between blended NPSB application rates and sesame varieties was also significant ($p<0.05$). Maximum oil yield (616.16 kg ha^{-1}) was noted when sesame variety Setit-2 applied with 100 kg ha^{-1} blended NPSB fertilizer application rate (Table 8) and the minimum (222.18 kg ha^{-1}) was recorded from Gonder^{-1} variety from no fertilizer applied (control) plot. The result suggested association of highest seed yield hectare^{-1} for oil yield production and maximum integrated nutrition. This result is in line with [28], who reported higher oil yield was obtained from plants fertilized with nitrogen at the rate of 100 kg ha^{-1} while less oil yield was obtained from control plots. Sulphur fertilization significantly increased the oil yield in plots treated with maximum Sulphur fertilization (40 kg ha^{-1}) reported by [49].

Table 9 Oil yield of sesame as affected by interaction sesame varieties and blended NPSB rate at Konso during 2020 cropping season

NPSB (kg ha^{-1})					
Variety	**0**	**50**	**100**	**150**	**200**
Setit-1	300.41^{d}	409.15^{c}	516.43^{b}	427.45^{c}	431.27^{c}
Setit-2	317.27^{d}	392.73^{c}	616.16^{a}	479.51^{b}	477.62^{b}
Gonder-1	222.18^{e}	327.52^{d}	423.64^{c}	415.26^{c}	403.91^{c}
Grand mean	410.72				
CV (%)	5.9				

Note: Mean values followed by the same letters are not significantly different at 5% level of significance

4 Conclusion

Results of analysis of variance indicated that crop growth, crop phenology, yield and yield components of sesame varieties were significantly affected due to application of blended NPSB fertilizer rates. Therefore, it is concluded that application of blended NPSB fertilizer rate of 100 kg ha^{-1} and sesame variety Setit-2 found to be important for growth, yield, yield components and oil yield of sesame production at Konso.

Compliance with ethical standards

Acknowledgments

I would like to thank Konso District Administration for financial support. My gratitude also goes to Areka Agricultural Research Centre (AARC) for providing sesame seed varieties to this research work. I would like to acknowledge Wondo Genet Agricultural Research Centre (WGARC) for Laboratory service.

Disclosure of conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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