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Effects of Seed Rate on Yield and Yield Components of Sesame (*Sesamum indicum* L.) in Arba Minch Zuria and Melokoza Districts

Yimegnushal Filimon[1*] and Alemayehu Wodajo[2]
Department of Agricultural Science, Arba Minch University, Arba Mich, Ethiopia

Abstract

A field experiment was carried out during the 2018 main cropping season from July to November in Arba Minch Zuria and Melokoza districts on farmer's fields to determine the optimum seed rate for sesame production in the study areas. The experiment was laid out in randomized complete block design with three replications. The result indicated that seed rate significantly ($p<0.05$) affected the number of branches and capsules per plant at Chano (Arba Minch Zuria) whereas a significant effect was noted in plant height, number of branches and grain yield at Melokoza. Maximum (677 kg ha^{-1}) grain yield was obtained from seed rate 2 kg ha^{-1} while the minimum grain yield (223 kg ha^{-1}) was obtained from seed rate 5 kg ha^{-1}. In the case of Arba Minch Zuria, there was no significant variation among all treatments. Economic analysis showed that seed rate 2 kg ha^{-1} was resulted in the maximum net benefit of about 21215 Birr ha^{-1} as compared to others. Therefore, it could be concluded that cultivating sesame using a 2 kg ha^{-1} seed rate is economical and could be recommended for both locations. However, it is advisable to undertake further research across soil type, years and locations to draw sound recommendation.

Keywords: Net benefit; Productivity; Seed rate; Sesame

Introduction

Sesame (*Sesamum indicm* L.) is an annual crop and it belongs to the order Tubiflorae and family Pedaliaceae cultivated for seed [1]. Sesame is considered one of the most important oil crops in the world because its seeds have high contents of oil and protein. The seeds contain about 50-60% oil and it is of excellent quality due to the presence of natural antioxidants such as sesamol and sesamol [2].

India and China are the world's largest producers of sesame, followed by Myanmar, Sudan, Uganda, Ethiopia, Nigeria, Tanzania, Pakistan and Paraguay (FAOSTAT, 2008). The oilseeds sector is one of Ethiopia's fastest growing and important sectors, both in terms of its foreign exchange earnings and as a main source of income for over three million Ethiopians. Study reports indicate that Ethiopia is among the six producers of sesame seed, linseed and Niger seed in the world. The area under sesame production in Ethiopia is currently 406,490.5 hectare (32.2%) with a total production of 276985.9 tons. The major sesame seed-producing areas are situated in the North West and South West Ethiopian in Humera, North Gondar and Wollega [3].

The average productivity of sesame is about 0.69 tons ha^{-1} which is lower than the yield from the experimental station (1.2 tons ha^{-1}) [4]. A survey conducted by Arba Minch research center to identify priority research areas showed that low productivity has discouraged sesame growers/potential growers in districts such as Melokoza, Kucha, Demba Gofa Mirab Abaya, Derashe, Konso, Arbaminch Zuria, Uba Debre Tsehay, Zala, Kemba, Boreda and Basketo special. The main reason for low production is poor agronomic practice such as, lack of knowledge on fertilizer rate, use of improper seed rate which ranges 5-10 kg ha^{-1} and disease and insect pests. Seed rate 1 kg ha^{-1} has been recommended for sesame production at the national level. But the producer complains that 1 kg ha^{-1} is difficult to manage during sowing. Planting using optimum seed rate has remarkable contribution in increasing quality of sesame, besides enhancing of its productivity; because seed rate has a direct effect on oil, protein contents, amino acids and fatty acids. Therefore, the objective of the current study was to determine the optimum seed rate for sesame production in Arba Minch Zuria and Melokoza districts.

Material and Methods

Description of the study area

The field experiment was conducted at Chano Mille and Salyish kebele of Arba Minch Zuria and Melokoza districts respectively during 2018. Chano Mille is located at an altitude of 1216 masl and lies in between 6° 6' 55" and 37° 35' 51" latitude and longitude ranges, respectively. According to the ten years of climatic data, the area is attributed with a bimodal rainfall pattern with a mean annual rainfall of 956.4 mm. The study site has minimum and maximum air temperatures of 17.2 and 30.3^{oc}, respectively (National Meteorological Agency of Ethiopia (NMAE), 2017). On the other hand, Salyish is located at an altitude of 835 masl and lies in between 06° 25' 059" and 036° 28' 074" latitude and longitude ranges, respectively.

***Corresponding author:** Yimegnushal Filimon, Department of Agricultural Science, Arba Minch University, Arba Mich, Ethiopia, Tel: 912458206; E-mail: yimuye28@gmail.com

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Treatments and experimental design and management

The treatments consisted of seven seed rates (1, 2, 3, 4, 5, 6 and 7 kg ha^{-1}) and were laid out using randomized complete block design with 3 replications.

The field was plowed following the conventional tillage practice before planting. The plowed land was harrowed and leveled manually to make easy the field layout and germination. The land was divided into plots and blocks. The gross plot size was 16 m^2 with 4 m width and 4 m length. The net plot area was 12.8 m^2; the spacing between rows was 0.4 m. Treatments were assigned to each plot randomly. The central eight rows in the net plot area were used for data collection.

Sesame variety called Humera^{-1} was used for the experiment and the seeds had 96.3 % germination power. The fertilizer application was based on the recommendation of the area. Hence, 100 kg ha^{-1} NPS (19% N and 38% P_2O_5 7S) and 50 kg ha^{-1} Urea were used as sources of N and P nutrients. The entire NPS fertilizer doses were drilled in rows just before sowing; however, urea was applied in splits before flowering. Recommended crop management practices such as weeding, pest and disease control were done uniformly for all experimental plots. Hand weeding and shallow cultivation were conducted twice during the period between two weeks after sowing and flower initiation. Fusarium wilt at the late pod setting stage was observed in the trial and recommended chemical was applied in the field. The crop from the net plot area was harvested manually when 90% of the leaves and capsules turned yellow and dried under the sun for 4 days before threshing.

Data collection and analysis

The number of branches per plant was counted from five randomly selected plants at physiological maturity. The plant height of the main stem was measured from the ground surface to the tip of the apex at physiological maturity. The number of capsules per plant was counted from five randomly selected plants at the physiological maturity of the crop. The number of seeds per capsule was counted from five randomly selected plants. The grain yield of each plot was weighed in grams and converted to yield per hectare in kg ha^{-1}. 1000 seeds were counted from the bulk of seeds and weighed using a sensitive balance in gram (g). Collected data were subjected to Analysis of Variance (ANOVA) following the design of the appropriate procedure using Proc Glm SAS version 9 for the factorial experiment. Means of significant treatment effects were separated using the Least Significant Difference (LSD) test at a 5% level of significance.

Economic analysis

An economic assessment was done using a partial budget procedure as described by CIMMYT (1988). The variable costs of seed and grain were gathered from Gamo Gofa Zone Cooperative and Marketing Department. The market price of sesame (35 birr kg^{-1}) was determined by assessing markets at harvest. The average yield was adjusted downward by 10% to reflect the farmer's field yield as described by CIMMYT (1988). Net benefit was calculated as total gross return minus total variable cost. A treatment that was non-dominated and had a marginal rate return of greater or equal to 100% and the highest net benefit was assumed to be economically beneficial (CIMMYT, 1988).

Results and Discussion

Plant height: The analysis of variance indicated that seeding rate had no significant (P<0.05) effect on plant height at Chano; however, in the case of Melokoza significant effect was observed. The tallest (162.07 cm) plant height was observed from 3 kg ha^{-1} whereas shortest (132.63 cm) from 7 kg ha^{-1} seeding rate at Melokoza. Seed rate 3 kg ha^{-1} was statistically at par with 1 kg ha^{-1}, 2 kg ha^{-1}, 4 kg ha^{-1} and 5 kg ha^{-1} in affecting plant height. Relatively plant height was higher at lower seed rates. The increase in plant height in response to reduced seed rate might be due to less competition for nutrients at wider spacing. Shreds of evidence reported by Ahmed and El Naim showed that plant density had no significant effect on plant height whereas Ngala and Valiki stated that an increase in planting population markedly would increase plant height (Table 1).

Seed rate (kg ha^{-1})	Chano		Melokoza	
	PH	NBP	PH	NBP
1	164.6	8.87^{a}	149.93^{ab}	12.47^{ab}
2	177.8	6.53^{b}	150.93^{ab}	13.47^{ab}
3	159.33	4.93^{c}	162.07^{a}	11.2^{abc}
4	166.13	4.67^{cd}	148.53^{ab}	14.67^{a}
5	163.4	3.80^{cd}	159.60^{a}	9.87^{bc}
6	169	3.47^{d}	143.67^{bc}	9.67^{bc}
7	171.87	4.53^{cd}	132.63^{c}	7.0^{c}
LSD	NS	1.21	14.87	4.22
CV	5.2	13.1	5.7	21.5

Mean values within columns followed by different letters are significantly different at P<0.05; NS denotes not significant at 5% level; P^{H} denotes plant height and NBP denotes the number of branches per plant.

Table 1: Growth parameters as affected by seed rate at Chano and Melokoza during 2018 cropping season.

Number of branches: The analysis of variance indicated that the seeding rate had a significant (P<0.05) effect on the number of the branch in both locations. In the case of Chano, maximum (8.87) and minimum (3.47) branch number per plant was recorded at 1 kg ha^{-1} and 6 kg ha^{-1} seeding rate respectively, whereas in the case of Melokoza maximum (14.67) and minimum (7) branch number per plant was recorded at 4 kg ha^{-1} and 7 kg ha^{-1} seeding rate, respectively. Seed rate 4 kg ha^{-1} was statistically at par with 1 kg ha^{-1}, 2 kg ha^{-1} and 3 kg ha^{-1} at Melokoza. Ahmed and Lakew observed the maximum number of branches with the lowest seed rate in sesame.

Yield and yield components of sesame

Capsules number: The analysis of variance indicated that the seeding rate had a significant (P<0.05) effect on capsules number per plant at Chano; however had no significant effect in the case of Melokoza. Maximum (135.07) and minimum (46.2) number of capsules per plant was recorded in 1 kg ha^{-1} and 7 kg ha^{-1} seeding rate, respectively at Chano (Table 2). This might be due to plants grown at a low seed rate receiving higher light, nutrients and water as compared to the highest seed rate which caused a greater number of capsules per plant at the lowest seed rate. This result was in agreement with the findings of Ahmed and Lakew who reported that the number of capsules per plant of sesame decreased with close planting. Similarly, Caliskan reported that the highest numbers of capsules were obtained from the lowest plant population or seed rate.

Seed rates (kg ha^{-1})	Chano			Melokoza			
	NCP	GY (kg ha^{-1})	TSW (g)	NCP	NSC	GY (kg ha^{-1})	TSW (g)
1	135.07^{a}	578.9	3	106.6	66.6	266.7^{c}	4^{a}
2	122.60^{ab}	597.4	4	81.97	62.6	677.3^{a}	4.3^{a}
3	53.67^{c}	467.4	3.7	89.87	65.67	526.7^{ab}	3.7^{ab}
4	67.33^{bc}	513.8	3.7	84.07	65.47	558^{a}	3.7^{ab}
5	46.40 ^{c}	563.3	3	74.47	56.8	223.3^{c}	3 ^{b}
6	65.20^{bc}	484.4	3.7	91.27	74	248.6^{c}	3^{b}
7	46.20^{c}	517.4	3.3	75.53	69.87	372.7^{bc}	3^{b}
LSD	61.3	NS	NS	NS	NS	164.7	0.93
CV	45.6	26	16.6	27.5	16.4	22.9	15.1
Mean values within columns followed by different letters are significantly different at P<0.05; NS denotes not significant at 5% level; NCP denotes of number capsules per plant, NSC denotes of number seed per capsules; GY denotes grain yield and TSW denotes thousand seed weight.							

Table 2: The yield and yield components as affected by seed rate on sesame at Chano and Melokoza during the 2018 cropping season.

Thousand seed weight: As presented in Table 2, the analysis of variance showed that the thousand seed weight was significantly (P<0.05) affected by seed rate at Melokoza, however, no significant variation was observed in the case of Chano. Maximum (4.3 gm) thousand seed weight was obtained from seed rate 2 kg ha^{-1} while the minimum thousand seed weight (3 gm) was obtained from seed rate 5, 6 and 7 kg ha^{-1} at Melokoza. Similar results were observed by Lakew.

Grain yield: As presented in Table 2, the analysis of variance of grain yield showed that the grain yield was significantly (P<0.05) affected by seed rate at Melokoza, however, no significant variation was observed at Chano. Maximum (677.3 kg ha^{-1}) grain yield was obtained from seed rate 2 kg ha^{-1} while the minimum grain yield (223.3 kg ha^{-1}) was obtained from seed rate 5 kg ha^{-1} at Melokoza. Use of seed rate 2 kg ha^{-1} resulted in the maximum grain yields of the sesame at Melokoza, however not significantly different as compared to seed rate 3 kg ha^{-1} and 4 kg ha^{-1}. The significant difference among treatments for grain yield could be due to variation in grain yield associated with traits such as the number of branches, capsules per plant and thousand seed weight. The increase in grain yield as seed rate decreased could be because of an increase in the number of branches and capsules per plant and thousand seed weights with the lowest seed rate. Furthermore plants grown at the lowest seed rate could receive relatively high light, moisture and nutrient as compared to plants grown at the highest seed rate. Similar results have also been reported for sesame [5]. Even though variations among treatments in grain yield in this experiment, the overall grain yield was low as compared to the national average and the crop potential due to occurrence of fusarium wilt (10-15% yield loss) and shortage of soil moisture at late pod setting stage [6-10].

Correlation analysis: Grain yield was positively correlated with the number of branches per plant ($r=0.55^{*}$), plant height (r=0.23 ns), number of capsules per plant(r=0.12 ns), number of seeds per capsules (r=0.05 ns), thousand seed weight (0.06 ns) (Table 3). However significant correlation was observed only with the number of branches per plant. The observation verifies that the increase in grain yield due to the use of reduced seed rate was a result of an improvement in main branch number and some effect also due to plant height, number capsules per plant and number of seed per capsules [11-13].

	P^H	NCP	NSC	NBP	GY	TSW
P^H	1	0.43*	-0.03 NS	0.48*	0.23 NS	0.09^{ns}
NCP		1	0.29 NS	0.47*	0.12 NS	0.51*
NSC			1	-0.06 NS	0.05 NS	0.29^{ns}
NBP				1	0.55*	0.21^{ns}
GY					1	0.06^{ns}
TSW						1

*denotes significantly different at P<0.05; NS denotes not significant at 5% level; pH denotes plant height, NCP denotes of number capsules per plant, NSC denotes the number of seed per capsules, NBP denotes the number of branches per plant, TSW denotes 1000 seed weight and GY denotes Grain Yield.

Table 3: Correlation analysis of growth, yield and yield component of Sesame.

Partial budget analysis: A partial budget analysis was carried out to evaluate the economic performance of different seeding rates. The result of the dominance analysis in Table 4 indicates that seed rate 3,4,5,6 and 7 kg ha^{-1} were dominated by the other treatments with a lower total cost that varied. This indicates that the dominated treatments involve higher costs but do not generate higher benefits as compared with other non-dominated treatments. Farmers generally preferred alternatives that give higher net benefit with least cost. Due to this reason the dominated treatments were rejected from further economic analysis, where as non dominated treatments are first ranked from lowest to highest in terms of total costs that vary and MRR was analyzed according to CIMMYT (1988) procedures and presented in Table 4.

The partial budget analysis indicated that the use of seed rate 2 kg ha^{-1} produced the highest net benefit (21214.95 Birr ha^{-1}) with an acceptable marginal rate of return compared to another seed rate. Therefore, 2 kg/ha was economically feasible for sesame production in the study area [14,15].

Seed rates (kgha^{-1})	GY (kg/ha)	AGY (kg/ha)	GB (ETB ha^{-1})	TCV (ETB ha^{-1})	NB (ETB ha^{-1})	MRR (%)
1	266.7	240.03	8401.05	60	8341.05	-
2	677.3	609.57	21334.95	120	21214.95	21456.5
3	526.7	474.03	16591.05	180	16411.05	D
4	558	502.2	17577	240	17337	D
5	223.3	200.97	7033.95	300	6733.95	D
6	248.6	223.74	7830.9	360	7470.9	D
7	372.7	335.43	11740.05	420	11320.05	D

D denotes dominated treatments, ETB denotes Ethiopian Birr (currency), TCV denotes Total Cost that Varies; GY denotes Grain Yield, AGY denotes Adjusted Grain Yield, GB denotes Gross benefit, NB denotes Net benefit and MRR denotes Marginal Rate of Return.

Table 4: Results of the partial budget analysis for sesame at Melakoza.

Conclusion

The study result indicated that seed rate significantly (p<0.05) affected the number of branches and capsules per plant at Chano whereas a significant effect was noted in plant height, number of branches, grain yield and thousand seed weight at Melakoza. Maximum (677.3 kg ha^{-1}) grain yield was obtained from seed rate 2 kg ha^{-1} while the minimum grain yield (223.3 kg ha^{-1}) was obtained from seed rate 5 kg ha^{-1} at Melokoza. Although the use of a seed rate of 2 kg ha^{-1} resulted in the maximum grain yield at Melokoza, it was not significantly different from the seed rate of 3 kg ha^{-1} and 4 kg ha^{-1}. In the case of Chano, their non-significant yield variation was observed among all treatments. Partial budget analysis showed that seed rate 2 kg ha^{-1} resulted in a maximum net benefit of about 21215 Birr ha^{-1} as compared to others. It could, thus, be concluded that cultivating sesame with a 2 kg ha^{-1} seed rate was the most productive and economical for small holder farmers in the study area. However, it is advisable to undertake further research across soil type, years, and locations to draw sound recommendations on a wider scale.

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