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Investigating Optimum Seed Rate for Maximum Productivity Potential of Sesame (*Sesamumindicum* L.) in Tigray, Ethiopia

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Abstract

Sesame is a very important and healthy oil crop. Seed rate (Plant density) is a prerequisite for obtaining higher yield. Decision on the optimum seed rate for sole cropping of sesame using widely cultivated variety in specific agroecology is essential. For two consecutive rainy seasons, a field experiment using RCBD was carried out in the Humera and Dansha areas of Tigray, Ethiopia, with nine broadcasting seed rate treatments ranging from 1 kg ha^{-1} to 9 kg ha^{-1}. Grain yield, plant height, number of pods per plant, length of capsule bearing zone, number of branches per plant, days of 50% flowering, days of 90% maturity, and agronomic data were collected to establish the ideal seed rate. Analysis of variance showed, that 3 Kg ha^{-1} is the optimism seed rate producing the highest yield (700.6 kg ha^{-1}).

Keywords: *sesame, seed rate, yield.*

Introduction

Sesame (*Sesamumindicum* L.), one of the world's most important oil crops, is known for having a high percentage of oil and protein (between 50 and 60 percent) in its seeds [1, 2].Ethiopia grows sesame primarily for the market and for its oil-containing seed.

According to the statement, the following elements influence plant population or seed rate: row width, crop species, soil and climate conditions, and agricultural use. Genetic and environmental factors affect plant density [3], [4]. [5] shown how plant density can impact a variety of traits, including seed yield, dry matter production, vegetative development duration, light conversion efficiency, canopy design, and crop economic productivity. Thus, the first stage in increasing production is to optimize plant density, which is the number of plants per unit area as well as the arrangement (spacing) of the plants on the ground.

[6] Several studies have found that the rates of sesame seeds vary by location based on specific conditions. [7] Rain-fed sesame planting produced the highest yields, 1.5 and 2.0 kg ha^{-1}, in the Sudanese state of North Kordofan. However, [2] showed that increasing the seed rate from 6 to 9 kg ha^{-1} boosted seed production.

For sesame single cropping, determining the seed rate is crucial. The government suggests an extraordinarily high 7–10 kg ha^{-1} for rain-fed sesame output in the Humera, Tigray, North West Ethiopia, based on observation studies. Sesame broadcasting sowing density has not been studied, despite the fact that hundreds of farmers in northern west Ethiopia use the broadcasting sowing technique. Determining the ideal spread seed rate for rain-fed production in the arid lowlands of North Western Ethiopia was the aim of this experiment.

Materials and Methods

An explanation of the materials and experimental site

The Humera Agricultural Research Center carried out a field trial in the Humera and Dansh districts of northwest Ethiopia during the main cropping season of 2010 and 2011 under rain-fed circumstances. Vertisol is the predominant soil reference group in the region [8].

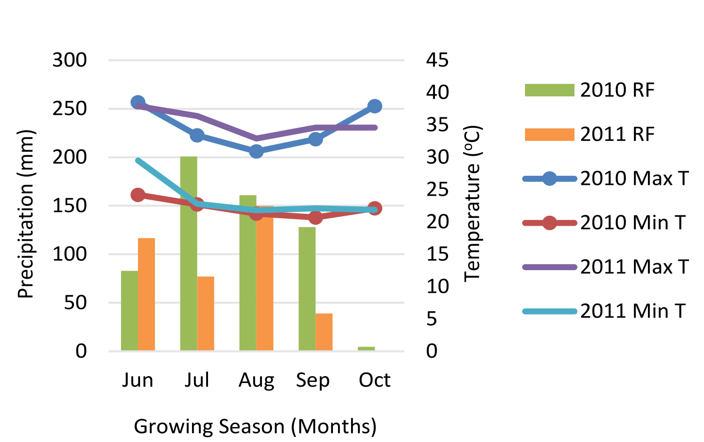

Figure 1. Precipitation, minimum, and maximum temperatures of the test location over the 2010 and 2011 growth seasons. RF=rainfall (mm), Max T=maximum temperature, Min minimum temperature.

Prior to sowing, the area was harrowed and plowed using a moldboard attached to a tractor. Each plot's seeds were manually broadcast-planted by combining them with sand. Since all farmers employ the broadcasting method of sowing, we did the same. There was no fertilizer. Agronomic guidelines and/or farmer practices served as the basis for weeding and other cultural practices.

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For 2010 and 2011, planting took place from July 10 to July 13. Three replications of the randomized complete block design (RCBD) experiment each had a gross plot size of 10 m by 5 m. "Hirhir" a branching sesame cultivar that is widely produced in the area, was utilized. The following data were recorded: plant height, number of branches per plant, length of capsule bearing zone, number of pods per plant, days of 50% flowering, days of 90% maturity, and grain yield. Once the water content was adjusted to 7.5%, the seed yield of each net plot was weighed and converted to yield ha^{-1} [9].

Table 1. List of treatments

Treatment	Method of Sowing
1 Kg ha-1	Broadcasting
2 Kg ha^{-1}	Broadcasting
3 Kg ha^{-1}	Broadcasting
4 Kg ha^{-1}	Broadcasting
5 Kg ha^{-1}	Broadcasting
6 Kg ha^{-1}	Broadcasting
7 Kg ha^{-1}	Broadcasting
8 Kg ha^{-1}	Broadcasting
9 Kg ha^{-1}	Broadcasting

Statistical analysis and data processing

Using SAS software version 9.1 (SAS Institute Inc., SAS Campus Drive, Cary, North Carolina 27513, USA), analysis of variance was used to examine the impact of seed rate on sesame grain yield. Mean separations were assessed using Duncan's multiple range test (DMRT) at the 5% probability level whenever a significant effect of the treatments was found.

Result and Discussion

Data on grain output, days of 50% flowering, days of maturity, branches per plant, length of capsule bearing zone, plant height, and pods per plant were collected during a two-year sequential experiment on sesame seed rate in two settings (two locations). All of the recorded agronomic data show no discernible differences in the combined analysis of variance (ANOVA) of replication. Days of flowering and days of maturity are less significantly different from one another, but the combined ANOVA of environment (location) is very significant for grain seed yield, branch per plant, length of capsule bearing zone, plant height, and pods per plant. With the exception of blossoming and maturity days, which do not change significantly, all parameters show extremely significant differences between treatments alone and the environment with treatments combination (Table 2).

Table 2. Combined Mean Squares of the yield and yield components of sesame

SV	Yield	DF	DM	BPP	LCBZ	PH	PPP
Rep	405	1.231	1.01	1.0018	15.34	75.32	33.68
Env	110232***	45.935*	1266.59*	5.4811***	1841.68***	1440.68***	2215.71***
Trt	107902***	1.301	1.15	5.1451***	671.14***	1151.66***	1017.35***
Env:Trt	19832***	0.949	0.43	0.9133***	125.84***	199.33***	211.66***
Residuals	3941	0.651	0.58	0.2298	48.04	28.07	17.62

Note: *DF stands for Days of 50% flowering, DM stands for Days of 90% maturity, BPP stands for number of branches per plant, LCBZ stands for Length of capsules bearing zone, PH stands for plant height, PPP stands for number of pods per plant.*

Days of 50% Flowering

In contrast to the findings of [10], who asserted that there were significant changes in the number of days needed for 50% of the plants to blossom among seed rate treatments, the number of days of 50% flowering is not substantially different for all treatments (Table 3).

Days Maturity

Days of 90% maturity (DM) is not significantly different for all treatments except for 2 kg ha^{-1}is highly significantly different than 6kg/ha (Table 3). The planting rate of 2 kg ha^{-1} of plants had a noteworthy and favorable impact on the remaining days until a plot achieved 50% physiological maturity [10].

Branches per Pant

Significant differences in primary branches per plant were found for seed rate treatments (Table 3). Generally speaking, the number of branches per plant declines as the seed rate rises. Higher seed seed-rates, like 7 kg ha^{-1}, 8 kg ha^{-1}, and 9 kg ha^{-1}, differ greatly from lesser seed-rates, like 1 kg ha^{-1}, 2 kg ha^{-1}, and 3 kg ha^{-1}, in terms of the number of branches per plant (BPP).According to [1, 2, 7, 11, and 12], higher seed rates resulted in lower BPP, while lower seed rates had the highest BPP.The BPP of 3 kg ha^{-1} differs significantly from that of other treatments (Table 3).[2] Among other things, the plants' increased access to water and space likely helped them grow more primary branches per plant^{-1} at a lower seed rate.

The amount of branches per plant is a critical growth component that has a big impact on output. As a result, 3 kg ha^{-1} is the ideal seed rate since it produced the greatest amount of BPP, which increased yield. The results of this investigation supported the findings of [13, 14], who observed that sesame plants had more branches at lower densities. In a similar finding, [15] noted that fewer branches were present in plants with larger populations.

Length Capsules Bearing Zone

Treatments showed highly significant differences in the Length of the capsule bearing zone (LCBZ) (Table 3). In general, as seed rate increases LCBZ decreases immediately in branched sesame cultivars. 1 kg ha^{-1}seed rate is highly significantly different (LCBZ) from all treatments. Treatments from 4kg ha^{-1}-9kg ha^{-1} are significantly lower LCBZ than other treatments.

Plant Height

Treatments show significant differences regarding Plant height (PH) (Table 3). 1 kg ha^{-1}and 2 kg ha^{-1}are significantly higher from all treatments. Despite the fact that 8 kg ha^{-1} is taller than 9 kg ha^{-1}, both 8 kg ha^{-1} and 9 kg ha^{-1} had significantly lower PH than the other treatments. Similar to [10], who reported that plants cultivated at a lower seeding rate of 2 kg ha^{-1} generated the tallest plants (117.77 cm), whereas plants grown at a greater seeding rate of 6.5 kg ha^{-1} produced the lowest plant height (97.04 cm). As the seed rate rose, plant height fell. The other encouraging finding was by [14], who found that taller plants were produced at lower densities, contrary to [7,11], who claimed that raising the seed rate from 2 to 8 kg ha^{-1} had no discernible impact on plant height.

Pods per Plant

The lower seed rate condition (3 kg ha^{-1}) produced the most pods per plant (Table 3). This is consistent with the findings of [13], who reported that the lower population produced the greatest amount of capsules per plant.

Grain Yield

Grain production was rising up to a seed rate of 3 kg ha^{-1} (Table 3). However, at seed rates higher than 3 kg ha^{-1}, grain yield declines. Although it is not much different from the 2 kg ha^{-1} (667.4 kg ha^{-1}) treatment, the grain yield at 3 kg ha^{-1} (700.6 kg ha^{-1}) is significantly higher than the other treatments. The 3 kg ha^{-1} seed rate yields a larger yield than the 2 kg ha^{-1} seed rate, although not being statistically substantially higher. In contrast to [2] findings, which indicated that seed yield increased when the seed rate was increased from 6 to 9 kg ha^{-1}, our research supports [11] recommendation that the optimal seed rate for growing sesame under rain-fed conditions in North Shewa, Ethiopia, is between 2 and 4 kg ha^{-1}. This is because our research produced a higher grain yield.Higher plant densities, on the other hand, increase intra-specific competition for light and nutrients, which reduces grain yield, claims [16].

Similar to the results of [11], the treatment with the highest BPP (3.3) and yield (700.6 kg ha^{-1}) was 3 kg ha^{-1} seed rate. Additionally, this treatment produced the most pods per plant (51.5).

This indicates highest BPP and PPP have the advantage of increasing yield or give the highest yield. From this finding the higher number of BPP and PPP gave higher yield. It was most likely caused by the branches growing more numerous as the seed rate decreased, potentially offsetting the greater seed rates. Depending on these findings PPPs are very important agronomic traits predicting the highest yield. The highest BPP indicates the highest PPP. Both the highest BPP and highest PPP indicate the highest grain yield.

Table 3. Sesame yield and yield components as impacted by varying seed rates

Treatment	DF	DM	BPP	LCBZ (cm)	PH (cm)	PPP	Yield(Kg ha^{-1})
1 Kg ha-1	40.8	83.3^{ab}	3.3^{ab}	63.2^{a}	113.3^{a}	46.3^{b}	523.5^{cd}
2Kg ha^{-1}	40.8	83.6^{a}	2.9^{bc}	56.5^{b}	109.9^{a}	32.8^{cd}	667.4^{ab}
3Kg ha^{-1}	40.8	82.9^{bc}	3.3^{a}	56.6^{b}	103.7^{b}	51.5^{a}	700.6^{a}
4Kg ha^{-1}	40.7	82.8^{bc}	2.6^{c}	44.9^{c}	99.3^{c}	28.9^{ef}	627.1^{b}
5Kg ha^{-1}	40.3	82.9^{bc}	1.8^{de}	44.7^{c}	96.9^{cd}	34.9^{c}	541.4^{c}
6Kg ha^{-1}	40.3	82.6^{c}	1.9^{de}	46.6^{c}	94.9^{de}	29.8^{de}	452.4^{ef}
7Kg ha^{-1}	40.5	82.9^{bc}	2.2^{d}	41.9^{c}	94.6^{de}	26.3^{fg}	480.8^{def}
8Kg ha^{-1}	39.8	82.7^{bc}	1.8^{de}	43.6^{c}	91.2^{e}	24.7^{g}	501.8^{cde}
9Kg ha^{-1}	40.4	83.1^{abc}	1.7^{e}	45.3^{c}	81.0^{f}	28.7^{ef}	439.8^{f}
Mean	40.5	83	2.4	49.3	98.3	33.8	548.3
LSD (<0.05)	ns	0.62	0.39	5.6	4.3	3.4	51.1
CV (%)	1.9	0.91	20	14	5.3	12.4	11.44

Note: *All treatments are broadcasting without thinning. DF stands for Days of 50% flowering, DM stands for Days of maturity, BPP stands for the number of branches per plant, LCBZ stands for Length of capsules bearing zone, PH stands for plant height, PPP stands for the number of pods per plant.*

Even though 3 Kg ha^{-1} seed rate show better yield for both the Humera and Dansha locations, the environmental mean yield of the Humera location is significantly higher than the environmental yield of the Dansha location. This indicates Humer environment is more suitable than Dansha for better sesame yield (Table 3).

The environmental yield difference observed was probably due to the adaptation difference of the variety to the growing conditions, and consequently, their relative yields differed in each environment. Humeralocation produced higher yields, as stated above, since better adaptation of the cultivar to the location. Our studies' findings demonstrate that the same seed rate treatment has different grain yields from year to year and from place to place. However, results suggest that a lower seeding rate (3kg ha^{-1}) may be adequate under optimum growing conditions.

Table 4. Mean Yield of sesame across growing environments as affected by different seed rates and environments

Treatment	Humera 2010	Humera 2011	Dansha 2010	Dansha 2011	Trt Mean
	E1	E2	E3	E4	
1 Kg ha-1	632.3	326.7	595.1	540.0	523.5
2 Kg ha^{-1}	724.0	744.3	621.3	580.0	667.4
3 Kg ha^{-1}	757.3	667.7	699.9	677.7	700.6
4 Kg ha^{-1}	700.7	714.0	519.2	574.7	627.1
5 Kg ha^{-1}	578.7	560.3	481.5	545.0	541.4
6 Kg ha^{-1}	416.7	553.3	384.1	455.7	452.4
7 Kg ha^{-1}	565.3	585.0	309.7	463.3	480.8
8 Kg ha^{-1}	626.0	620.0	385.5	375.7	501.8
9 Kg ha^{-1}	541.7	520.0	332.0	365.7	439.8
Env Mean	615.85a	587.93a	480.92b	508.63b	548.3

Conclusion

A higher BPP indicates a higher PPP. The higher BPP and higher PPP indicate a higher yield. BPP and PPP are the most important agronomic traits to predict grain yield under different seed rate treatments. For Humera and Dansah locations located in Northern West Ethiopia, 3 kg ha^{-1} sesame seed broadcasting is the optimum seed rate of sesame to give maximum potential yield. It is recommended to study seed rate with raw and intra-raw spacing of different varieties commonly used by farmers.

Conflicts of Interest

No conflicts of interest are disclosed by the writers. The study's design, data collection, analysis, and interpretation, article preparation, and publication of the results were all independent of the Tigray Agricultural Research Institute (TARI), the funding source.

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