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The effect of intra and inter-row spacing on growth, yield and yield attributes of sesame (*Sesamum indicum L.*) under irrigated condition in Benna Tsemay Distinct, South Omo Zone, Ethiopia

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ABSTRACT: Sesame is cultivated almost in all the tropical and subtropical countries of Asia and Africa. However, the yield of this crop is limited due to the lack of appropriate plant density among others discourage factors. Therefore, the field study was conducted during the 2018 and 2019 planting season with the objective of evaluating the effect of intra and inter-row spacing on yield and yield attributes of sesame in Weyito, South Omo Zone and Southern Ethiopia. This field study was factorial with three inter-row spacing (30, 40 and 50 cm) and three intra-row spacing (10, 15 and 20 cm) and used randomized complete block design with three replications. Number of primary branches per plant, plant height, number of capsules per plant, thousand seed weight and grain yield data were recorded and subjected to statistical analysis. The results of this study showed that there was a highly significant ($p<0.01$) difference among the main effect inter and intra-row spacing in number of primary branches per plant, plant height, number of capsules per plant, thousand seed weight and grain. The highest (1.19 ton per hectare) and (1.04 ton per hectare) grain yields were obtained from 15 cm intra and 40 cm inter-row spacing, respectively. Therefore, the use of 40 cm inter row and 15 cm intra row spacing can be recommended for sesame producing farmers to attain the higher grain yield of sesame at the study area and similar soil and climatic factors areas.

Keywords: Grain yield, inter-row spacing, intra-row spacing, sesame.

INTRODUCTION

Sesame (*Sesamum indicum L.*) is a diploid species with 2n = 26 chromosomes. It is a self-pollinated crop, which is under the family of pendaliacea. Sesame is called the queen of oil crops (Ercan et al., 2004). Sesame is the crop of tropics and in some temperate areas. It grows best on the area which is with an altitude of 500 to 800 meter above sea level. It needs a growing period of 70 to 150 days. The maximum pH for growth ranges from 5.4 to 6.7 and good drainage is crucial. It is susceptible to very acidic or saline soils. The optimum temperature for growth varies with varieties in the range 27 to 35°C. Period of high temperature above 40°C during flowering reduce or abort capsule and seed development. It requires from 600 to 1000 mm amount of water during growing period (Nath et al., 2000)

Sesame has used for a multiple purpose such as a source of food, eaten as raw, either roasted or parched, or as blended oil in the form of different sweets. Its seeds are rich a source of oil, protein, calcium, phosphorus and oxalic acid. Oplinger et al. (1990) reported that, part of attraction for sesame is undoubtedly is it high fat (50% oil) and protein content (up to 25% protein by weight). Getinet and Negusse (1997) reported that, sesame is important as cash crop, export commodity, raw materials for industries and as a source of employment opportunity in Ethiopia. A sizable proportion of the population, therefore, generates income from oilseed farming, trade and processing.

Low yield of sesame in Ethiopia is attributed to several production constraints which include shortage of improved varieties, poor cop management practices (inappropriate plant density, planting time etc), low soil fertility, moisture stress, diseases and insect pests (Gebremichael, 2011). The establishment of an adequate plant density is critical for utilization of available growth and development factors such as water, light, nutrient and carbon-dioxide and to maximize grain yield. Too wide spacing leads to low plant density per unit area and reduces ground cover, whereas too narrow spacing is related to intense competition between plants for growth factors (Singh et al., 2004). In general, increase in yield has been obtained with the increase in plant density to the optimum levels (Adeyemo et al.,1992; Olowe and Busari, 1994). On the other hand, the variation in plant density has been related to the variation in the number of capsules per plant, seed yield per plant and thousand seed weight (Bakhshandeh, 2006) and plant height, number of branches per plant and grain yield (Ngala et al., 2013).

In Ethiopia, sesame grow during main rainy season as well as under irrigation during off- season commonly using 5 kg/ha seed rate and 40 x 10 m spacing (Gebremichael, 2011). The optimum plant density for maximum yield varies depend on plant characteristics, availability of growth factor such as nutrients and water. Thus, optimum plant density of a crop at one location may not be applicable at another location, due to variation in: soil character, and nutrient availability, and other environmental conditions. To solve these problems, the study was conducted with the following objectives:

1. To evaluate the effect of intra and inter-row spacing on growth, yield and yield components of sesame.
2. To determine the appropriate intra and inter row spacing to attain maximum grain yield of sesame

MATERIALS AND METHODS

Description of the study area

This field study was carried out at Weyito, Benna-Tsemay district which is located in South Omo Zone, Southern Nations, Nationalities and People's Regional State of Ethiopia during 2018 and 2019 cropping season. The district is situated between 5°01' and 5°73' North latitude and 36°38' and 37°07' East longitude with altitude of 588 m.a.s.l. The rainfall distribution of the area is bimodal with main rainy season extends from January to May and the second cropping season, from July to October. It receives annual average rainfall of 876.3 mm and the monthly average minimum and maximum temperatures of 18.2 and 34.3°C, respectively (National Metrological Agency Hawassa Brach, 2018). The soil of study site is sandy loam in texture. It has total nitrogen content of 0.086%, available phosphorus content of 29.355 mg kg^{-1} soil and soil pH of 6.1.

Experimental design and treatments

The field experiment was factorial with three inter-rows spacing (30, 40 and 50) cm and three intra-row spacing (10, 15 and 20) cm. Factorial combination was used as nine treatments arranged in a randomized complete block design with three replications. Sesame (variety 'Humera-1') was used for current study.

Experimental procedure and management

The land was ploughed, disked, and harrowed by tractor, after which seeds were sown by drill at inter-row spacing. Thinning was carried out two weeks after emergence to maintain the target intra-row spacing. A gross plot size of 3 m x 3 m was used for treatment of inter-rows of 30 and 50 cm, whereas 3 m x 3 m for 40 cm inter-row spacing. The number of rows per plot for the intra-row spacing; 30, 40 and 50 cm were 10, 8 and 6, respectively. The space between replications and plots were 2.0 and 1.0 m, respectively. The irrigation water was applied by the use of furrow irrigation at every 6-8 days from planting up to flowering and then every 10 days up to physiological maturity according to weather condition. The first, second and third weeding and hand hoeing were performed 20, 40 and 60 days after planting, respectively.

Data collected

Growth traits

Plant height (cm) was measured at the time of physiological maturity from central rows of five randomly taken sample plants from the soil surface to the apex of each plant. Number of branches per plant was determined by counting primary branches of randomly selected plants from central rows.

Yield and yield components

Number of capsules per plant was counted from five randomly sampled plants and the average value was considered**.** Thousand-seed weight (g) was recorded by taking weight of hundred randomly sampled seeds from the harvested central rows. The two central rows per plot were harvested, sun dried and threshed. The grain yield in kg from each plot was weighted using an electronic balance.

Table 1. Combined mean square values for plant height, branches per plant and capsules per plant, thousand seed weight and grain yield of research conducted at Weyito in South Omo Zone during 2018 and 2019 cropping season

Source	DF	PH	NPBPP	NCPP	TSW	GY
Rep	2	0.01 ^{ns}	0.063*	160.96*	0.01*	1.02*
Inter	2	0.09**	13.889**	17776.92**	1.18**	6.15**
Intra	2	0.65**	1.002**	495.21**	0.54**	12.91**
Year	1	0.29 ^{ns}	0.276 ^{ns}	167.26 ^{ns}	0.37 ^{ns}	1.86 ^{ns}
Inter x Intra	4	0.01^{ns}	0.93 ^{ns}	32.06 ^{ns}	0.10 ^{ns}	3.75 ^{ns}
Inter x Year	2	0.43^{ns}	0.67 ^{ns}	21.035 ^{ns}	0.01 ^{ns}	2.81 ^{ns}
Intra x Year	2	0.32^{ns}	0.91 ^{ns}	28.06 ^{ns}	0.15 ^{ns}	1.96 ^{ns}
Inter x Intra x Year	4	0.04^{ns}	0.78 ^{ns}	31.05 ^{ns}	0.26 ^{ns}	2.13 ^{ns}
Error	34	0.009	0.390	26.190	0.044	1.806
CV%		5.1	10.3	4.5	7.0	12.8

*, **, *** indicate significance at p<0.05, p<0.01, and p<0, respectively; 'NS,' non-significant. Inter =Inter-row spacing, Intra = Intra-row spacing, intra x inter =Intra-row spacing with inter row spacing, PH=plant height. NPBPP=Number of branches per plant, NCPP = Number of capsules per plant, TSW = Thousand seed weight and GY= Grain yield.

Statistical analysis

The analysis of variance was conducted for data collected using SAS software version 9.2 (SAS, 2008) with a generalized linear model (GLM) procedure. Mean separation was done using least significant differences (LSD) test at 5% level of significance. Since the error variable was homogenous, instead of year wise data, pooled values were given for discussion and interpretation.

RESULTS AND DISCUSSION

Growth traits

In this study, combined analysis of data over years revealed that main effect of inter and intra-row spacing were significantly ($p \leq 0.05$) influenced plant height and primary branches per plant, but the interaction effect was none significant (Table 1). The tallest plant height (1.9 m) was recorded in 30 and 10 cm inter and intra-row spacing, while the shortest plant height (1.5 m) and (1.6 m) were recorded from 50 inter-row spacing and 20 cm intra-row spacing, respectively (Table 2). Generally, increase in plant height with decreased plant spacing could be due to the fact that, as the spacing among plants decreases, the interplant competition for light increases and enhances apical growth. This result was in line with the findings of Ahmed et al. (2005) who reported that, an increase in plant population density with similar manner would be increase plant height.

The analysis of variance showed that, the main effect of inter and intra-row spacing revealed significantly ($p \leq 0.01$) affected number of branches per plant, although their interaction was non-significant effect (Table 1). The highest mean number of branch 6.8 and 7.4 per plant were recorded in 20 cm intra and 50 cm inter-rows spacing, respectively. On other hand the lowest 5.7 and 4.9 number of branches were recorded from at 10 cm intra and 20 cm inter-row spacing (Table 2). Increase primary branches with the decreased plant population density as per unit area might be due to the fact that as increased intra and inter-row spacing sufficient resources become available for each plant that in turn enhances the lateral branch growth. This result was in agreement with the finding of (Gebre, 2006) who obtained increased number of branches per plant at wider plant population density on sesame.

Yield and yield component

In this study, the main effects of inter and intra-row spacing were significantly influenced ($p<0.01$) on capsules per plant, thousand seed weight and grain yield, however their interaction effect was not significant (Table 1). The heights thousand seed weight (3.4 g) and (3.3 g) were recorded in 5 0cm inter-row and 20 cm intra-row spacing, respectively. While the lowest thousand seed weight (2.7 g) and (2.8 g) were recorded in 30 cm inter-row and 10 cm intra-row spacing, respectively. With regards to capsules per plant, the heights capsules per plant (130.4) and (122.7) were recorded in 50 cm inter-row and 20 cm intra-row spacing, respectively. While the lowest capsules per plant (103.7) and (107.9) were recorded in 30 cm inter-row and 10 cm intra-row spacing, respectively. With the increase in inter-row spacing from 30 to 50 cm and intra-row spacing from 10 to 20 cm, capsules per plant and thousand seed weight (g) increased (Table 2). This result was in line with the finding of Muluken and Balcha (2016) who obtained increased number of capsules per plant and thousand seed weight at the wider plant spacing. Similarly, El Naim et al. (2010) and Noorka et al. (2011) who reported increased number of branches and capsules per plant with increasing intra and inter- row spacing.

The highest grain yield (1.14 t ha^{-1}) was recorded in 40

Table 2. Combined mean values for primary branches per plant, plant height, capsules per plant, thousand seed weight and grain yield of research conducted at Weyito, South Omo Zone 2018 and 2019 cropping season.

Inter-row spacing (cm)	Plant height (m)	Branch number	Capsules per plant	Thousand seed weight (g)	Grain yield (t ha^{-1})
30	1.9^{a}	4.9^{c}	103.7^{c}	2.7^{c}	0.98^{c}
40	1.7^{b}	5.8^{b}	119.8^{b}	3.0b	1.14^{a}
50	1.5^{c}	7.4^{a}	130.4^{a}	3.4a	1.04^{b}
LSD 0.05	0.1	0.6	5.1	0.2	1.3
Intra-row spacing (cm)					
10	1.9^{a}	5.7^{b}	107.9^{c}	2.8^{c}	0.96^{b}
15	1.7^{b}	6.0^{b}	113.3^{b}	3.0^{b}	1.19^{a}
20	1.6^{b}	6.8^{a}	122.7^{a}	3.3^{a}	0.97^{b}
LSD 0.05	0.1	0.7	5.2	0.2	1.3

Note: Means with different letters are significantly different, LSD (0.05) = least significant difference at 5% level.

cm inter-row spacing, while the lowest grain yield (0.98 t ha^{-1}) was produced at 30 cm intra-row spacing. On other hand, the highest grain yield (1.17 t ha^{-1}) was recorded from 15 cm intra-row spacing, whereas the lowest grain yield (0.97 t ha^{-1}) was obtained at 20 cm intra-row spacing (Table 2). The reduced in grain yield below 15 cm intra-row spacing and 40 cm inter-row showed intense competition for light and nutrients below optimum spacing. On the other hand, at wider inter row spacing, the space could not be fully exploited to give higher grain yield. This result was in agreement with the finding of Ngala et al. (2013) who reported that, increased plant population density with increased competition between plants which eventually caused reduction in the number of capsules per plant. Similarly, Muluken and Balcha (2016) reported maximum grain yield of sesame in 40 cm inter-row spacing and 15 cm intra-row spacing.

Conclusions and Recommendation

The study result showed that on growth, yield and yield components such as number of primary branches per plant, plant height, number of capsules per plant, thousand seed weight and grain yield were significantly influenced by the main effect of intra and inter-row spacing. Capsules per plant and thousand seed weight increased with decreased plant population density. The maximum grain yield was recorded at 40 cm inter and 15cm intra row spacing. Therefore, from the results of this study, it can be recommended to use 40 cm inter and 15 cm intra-row spacing for increased sesame productivity at Weyito and its vicinity. However, this study was based on one location, thus requires further verification to fully recommend the specific plant density for the target area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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