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Determination of Optimum Inter-Row Spacing and Phosphorus Level for Sesame Production (Sesamum indicum L) Under Irrigation at Arbaminch Zurya District, Southern Ethiopia

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Abstract
Field trial was conducted in Arbaminch University Teaching and Research Farm from November2016 to March 2017 with the objective of determining optimum inter-row spacing and phosphorus level for sesame production under irrigation condition. The treatments comprised four inter-row spacings (30, 40, 50 and 60 cm) and four phosphorus levels (0, 10, 20, 30 kg/ha^{-1}). A randomized complete block design with three replications was used. Plots treated with 30 kg P ha^{-1} produced maximum, yield of straw (2.15 tonha^{-1}),seed (0.64 tonha^{-1}) and biomass (2.79 tonha^{-1}) while the control plots produced the smallest yield of straw (1.56 tonha^{-1}), seed (0.41 tone ha^{-1}) and biomass (1.97 tonha^{-1}). Grain yield was linearly related to increasing rates of phosphorus application while no further significant advantage was obtained for total biomass above the 20 kg ha^{-1} rate. Inter- row spacing of 30 cm gave maximum plant height (162.75 cm), straw yield (2.99 toneha^{-1}), seed yield (0.65 toneha^{-1}) and biological yield (2.95 tonha^{-1}).On the other hand, plants grown at 60 cm row spacing resulted in the highest branch per plant (11.7), number of capsule per plant (76.67) and harvest index (23 %)as compared to the other row spacings. Hence, application of Phosphorus at the rate of 30 kg ha^{-1} with an inter-row spacing 30cm could improve yield and yield components of sesame under irrigated condition of Arbaminch surrounding and areas with similar agro-ecological conditions. However, further study with inclusion of greater phosphorus level and narrower inter row spacing could be worthwhile to analyze the response of the crop more and in order to reach at a conclusive recommendation.
Keywords: *Sesamum indicum* L., Row spacing, Phosphorus levels, Seed yield, Yield components

1. INTRODUCTION

Oil crops are one of the principal sources of oils and fats. Growth and improvement of the oilseed sector can substantially contribute to the economic development at national, regional and family levels. Sesame seed has become one of the most important oilseeds for Ethiopia's export earnings and for increasing the potential of generating income for the local population. The production and productivity challenges of sesame were lack of widely adaptable verities, disease and pests and not using of improved agronomic activities or improved crop managements like optimum population, optimum fertilizer application, weeding time and frequency. Use of proper agronomic practices is one of the important factors which contribute for increase of yield per unit area. Applications of essential nutrients are very important to increase the production and productivity of the sesame crop. Phosphorus is an essential nutrient required by the plants for their growth and vigour. (Shahab *et al.,* 2015). Plant density is also one of the essential agronomic practices and yield responses to plant density need to be known for practical purposes, as it is a major management variable used in matching crop requirements to the environmental offer of resources (Smith and Hamel, 1999). In Ethiopia, the recommended spacing for sesame production is 40 cm x 10 cm for high seed yield production (EARO, 2004). Abdissa (2009) indicated that high yield of sesame was obtained at 30 cm x 15 cm (for unbranching) and at 40 cm x 10 cm for branching varieties. Gamo Gofa is one of the SNNPR zones that suitable for sesame production specially Kucha, Mellokoza and Arbaminch Zurya districts are very suitable areas for sesame and other oil crops like ground nut. However, the average productivity and for southern region is 5.2 quintal/hectare which is very low compared to the other regions of Ethiopia It is necessary to come up with optimum agronomic management practices suited to the region in order to realize the potential.

Objectives

To evaluate the response of irrigated sesame to different rates of Phosphorus fertilization and inter-row spacing and to identify the optimum inter-row spacing and optimum Phosphorus level for sesame production under irrigation

2. Material and methods

The field experiment was conducted under irrigated condition at Arbaminch-zuriya district GamoGofa zone in the Southern Nations Nationalities and people's Regional State from November 2016 to March 2017. The research field was 500 km NW from the capital city of Ethiopia Addis Ababa.

The experimental site is located at an elevation of 1183 masl with of 6° 041 70' N and 37° 341 28' E (Fig 1).

The climate of Arbaminch Zurya (shara) is characterized as arid to semi-arid agro-ecology. Rainfall pattern is characterized as bimodal having two rainy seasons and two dry seasons. The main rainy season extends from March to May and the short rainy season stretches from September to November. The mean annual rainfall of the area is 942 mm. The mean maximum and minimum annual temperatures are 30.3 and 17.6°C, respectively.

In this experiment, sesame variety setit-1 with white seed colour was used. The treatments consisted of four - row spacing (30, 40, 50 and 60 cm), and four Phosphorus levels (0.10, 20,30kg/ha). The four row spacing and the four Phosphorus levels were arranged in 4×4 factorials in randomized complete block design (RCBD) with 3 replications. The gross plot size was 15 m^2 with 3m width and 5m length. Spacing between plot and between replications were 1m and 1 m, respectively.

3. Results and discussion

Days to flowering and days to maturity

The analysis of variance showed that number of days to flowering and maturity was not significantly affected by phosphorus level, rows spacing and the interaction. The analysis of variance showed that number of days was not significantly affected by phosphorus level, rows spacing and the interaction (Table 1). This result was in contrast with the finding of Bachubhai *et al*.,(2016), who stated that days to flowering and maturity were affected by row spacing in sesame crop. Adam *et al.,*(2013) also stated that number of days to flowering was significantly delayed at 75 cm than 25 cm. Langham (2007) reported that at the same moisture and fertility, high populations use up the resources sooner and go through the whole development faster from the mid bloom to the late dry down stage. Probably, application of supplemental irrigation may have dampened the effects of the study factors on the duration that was required to attain flowering phase.

The number of days to physiological maturity of the plants in a plot was not significantly affected by the Phosphorus level, row spacing and the interaction (Table1).This result disagree with the finding of Bachubhai *et al.,*(2016) who reported that row spacing had significant effects on days to maturity. Accordingly narrow row spaced plants matured faster than wider row spacings because of limitation in resource for development. In this experiment, the inherent high soil N content and supplemental irrigation provided may have reduced the need to shorten developmental phases by plants.

Table 1: Effect of row spacing and Phosphorus level on days to flowering and days to maturity of sesame

Treatments P(kg ha^{-1})	Days to Flowering	Days to Maturity
0	35.42	87.25
10	36.17	87.83
20	35.83	88.41
30	36.33	87.92
Inter-row spacing		
30	35.67	87.58
40	35.25	87.91
50	36.25	87.08
60	36.58	87.83
CV(%)	6.77	2.72

Plant Growth Parameters

Results of this study indicated that plant height and branches per plant was not significantly ($P<0.05$) different due to Phosphorus application but the affected by spacings. The analysis of variance showed that the straw yield was significantly affected by Phosphorus level and row spacing while the interaction effect was not significant. Results of this study indicated that plant height was not significantly ($P<0.05$) different due to Phosphorus application. However, plant height was spacing significantly ($P < 0.01$) affected by row. The highest plant height of 163 cm was obtained from plants grown using 30 cm row plant spacing (Table 2). Conversely, the lowest plant height of 134 cm was measured from plants grown with 40 cm row plant spacing, which was not significantly different to 50 and 60 cm spacings. This result is in agreement with Asif *et al*., (2015) who showed that planting geometry affected the plant height of sesame significantly. Accordingly crops sown at planting geometry of 30 cm × 20 cm produced significantly taller plants than wider planting geometries considered in the study. The increase in plant height in narrower planting geometry was due to competition for light. When the number of plants per unit area increase, the competition for light increases resulting in taller plants. Decrease in inter-row spacing increased plant density, which probably increased competition for resources like sun light.

Number of primary branches is an important growth parameter which has considerable influence on yield. The analysis of variance showed that number of primary branches per plant was highly and significantly ($P<0.01$) affected by the row spacing but not by Phosphorus fertilization. The highest mean number of primary branches $plant^{-1}$ (11.7) was recorded for plants ha^{-1} grown at 60 inter-row spacing, whereas the lowest number of primary branches $plant^{-1}$ (6.42) was obtained from plants grown at 30cm row spacing (Table 2). In general, as the row spacing increased, the number of branches plant^{-1} also increased because of computation for resource this indicating the importance of row spacing than Phosphorus level in determining the number of branches plant^{-1}. These results contradict with the finding of Jakusko*et al*.,(2013) who stated that spacing had no significant effect on primary branches in sesame crop.

The analysis of variance showed that the straw yield was significantly affected by Phosphorus level and row spacing while the interaction effect was not significant. The maximum straw yield (2.15 ton ha^{-1}) was obtained from 30 kg of Phosphorus and the minimum straw yield (1.56 ton ha^{-1}) was obtained from control plot or 0 kg of Phosphorus (Table 2). This result was agreed with the finding of Ashwani. *et al*., (2015) who reported that straw yield was affected by application of Phosphorus fertilizer. However, further increase on Phosphorus rate above 30 kg ha^{-1} was not accompanied by a concomitant increase in straw yield. The effect of row spacing also had significant difference on straw yield and the maximum straw yield (2.3 ton ha^{-1}) was obtained from 30 cm row spacing while the minimum straw yield (1.65 ton ha^{-1}) was obtained from 60 cm row spacing. Narrow spacing gives higher straw yield because of its maximum population.

Table 2: Effect of row spacing and Phosphorus level on Plant height Branches per plant and Straw yield

Treatments			
P(kg ha^{-1})	Plant height(m)	Branches per plant	Straw yield (t ha^{-1})
0	143^{ns}	8.6^{ns}	1.56b
10	143^{ns}	8.5^{ns}	1.90a
20	142^{ns}	8.0^{ns}	2.06a
30	140^{ns}	9.2^{ns}	2.15a
Inter row spacing			
30	1630a	6.4c	2.30a
40	134b	6.8c	2.04b
50	136b	9.3b	1.68c
60	135b	11.8a	1.65c
CV(%)	4.45	23.77	15.50

Yield and Yield Components

Number of capsules plant^{-1} and thousand seed weight was not affected by Phosphorous level but yield showed significant difference. Except thousand seed weight both are affected by spacings. Number of capsules per plant was not significantly affected by Phosphorus level. This result was disagreed with the findings of Muhammad *et. al.,*(2014) who reported that Phosphorous application had significantly affected capsule plant^{-1}. On the other hand number of capsules plant^{-1} was affected by row spacing.The highest mean number of capsules plant^{-1} (76.67) was recorded for plants grown at 60 cm inter-row, while the lower number of capsules plant^{-1}were recorded for plants grown at 30 and 40cm inter-row spacing (Table 3). Like the effect on number of branches, as the row spacing increased, the number of capsules plant^{-1} also increased indicating the importance of row spacing. This result is similar with the finding of Amanullah *et al.,*(2014)who found out that row spacing had significant effect on number of capsules plant^{-1}, 60 cm row spacing had the highest (81) number of capsules plant^{-1} while the lowest (60) were from the narrow 30 cm row spacing. The average capsule number plant^{-1} decreased with reduction of spacing between rows leading to competition among plants that result in lower capsules number of plant.

Thousand seed weight was not significantly affected by Phosperus level and row spacing. This result was similar with the findings of Sevgi *etal.,*(2004)who stated that seed weight was not significantly influenced due to variation in population. On the other hand this result contradicted with the finding of Muhammad*et al.,*(2014) and Miam *et al.,* (2011) who showed that Phosphorus application had significant effect on thousand seeds weight. More doses of Phosphorus producing highest thousand seeds weight.

The analysis of variance showed that seed yield was highly and significantly ($P<0.01$) affected by Phosphorus level and inter-row spacing while the interaction effect was not significant (Appendix 3). There was a linear relationship between grain yield and applied Phosphorus rates (Fig 1). The highest seed yield (0.64 tonha^{-1}) was obtained from 30 kg of Phosphorus level and while the lowest seed yields (0.41 ton ha^{-1}) was recorded from control plot or (0 kg) of Phosphorus level (Table 3). This result is in agreement with the finding of Amanullah,(2014) who showed that applying of Phosphorus fertilizer increases yield of sesame by 91% and according to Miam *et al.,*(2011) yield of sesame increased 7.87kg/ha due to application of 1kg/ha of Phosphorus.

Row spacing also had significant difference effect on grain yield. The highest seed yield (0.65 ton ha-1) was obtained from 30 cm inter-row spacing, and the lowest seed yield (0.47 ton ha-1) was recorded from 60 cm inter-row spacing, which was at par to the 50 cm inter-row spacing. The decrease in seed yield at the widest row (60 cm) spacing could be due to low number of population. Higher seed yield at 30 cm was because of plants had more capsules and population per unit area more than compensating for loss on per plant basis. These characters are responsible to contribute major share toward seed yield in sesame. The finding of Ozturk (2012), Bachubhai et al.,(2016) showed that highest seed yield was obtained from the narrow row spacing (30 cm) where as the lowest seed yield was obtained from widest row spacing (70 cm). Similarly, Davut *et al*., (2007) stated that narrow row spacing gives higher seed yield than wider intra and inter row spacing.

Table 3: Main effects of capsule plant^{-1}, thousand seed weight and seed yield

Treatments P(kg ha^{-1})	Number of CapsulesPlant^{-1}	Thousand seed weight (gram)	Yield (t ha^{-1})
0	63.3^{ns}	3.00^{ns}	0.42d
10	54.8^{ns}	3.00 ^{ns}	0.50c
20	53.6^{ns}	3.00 ^{ns}	0.56b
30	51.5^{ns}	3.08 ^{ns}	0.64a
Inter-row spacing's			
30	42.1c	3.00^{ns}	0.656a
40	47.6cb	3.00^{ns}	0.51b
50	56.9b	3.00^{ns}	0.48cb
60	76.7a	3.08^{ns}	0.47c
CV(%)	29.2	4.78	8.44

Biological Yield and Harvest Index

Total above ground dry biomass yield was highly significantly (P<0.01) affected by both Phosphorus level and inter- row spacing. Harvest index was not affected by Phosphorus level but row spacing significantly affects harvest index. Total above ground dry biomass yield was highly significantly (P<0.01) affected by both Phosphorus level and inter- row spacing. Unlike grain yield total biomass production reached a plateau at the rate of 20 kg Phosphorus ha^{-1} (Fig.2). Accordingly, though the highest above ground total biomass weight (2.79 tonha^{-1}) was recorded from 30 kg of Phosphorus level it was statistically at par with that of 20 kg Phosphorus ha^{-1}.The lowest biological yield (1.970 tonha^{-1}) was obtained from 0 kg ha^{-1} of Phosphorus (Table 4). This result agrees with the finding of Amanullah *et al*.,(2014) who stated that Phosphorus application has significantly increased biological yield.

The highest recorded biological yield (2.95 ton ha^{-1}) was from 30cm inter-row spacing. In contrast, the lowest biomass yield (2.13 ton ha^{-1}) was obtained from 60cm inter-row spacing, which was not significantly different to that of 50 cm spacing. This result was in contrast with Amanullah.*et al.,*(2014) who obtained that 60 cm row spacing recorded maximum biological yield as compared to 30 cm row spacing, which gave minimum biological yield.

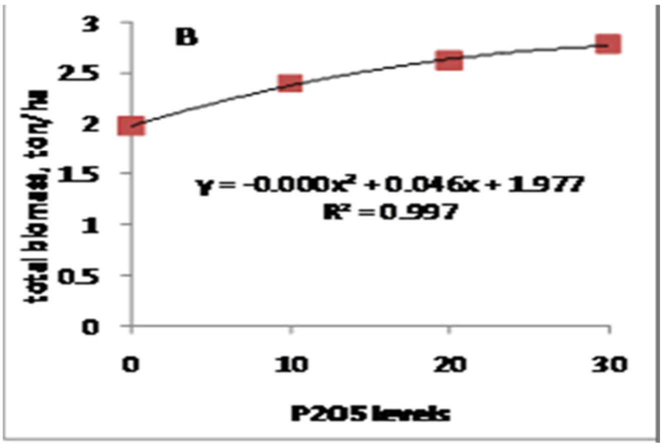

Figure 2: Relationship between applied P rates and total biomass

The analysis of variance showed that the harvest index was not affected by Phosphorus level but row spacing significantly affects harvest index. The interaction also had no significant effect. The maximum harvest index (23%) was obtained from 60cm row spacing and the minimum harvest index (19%) was obtained from 30cm row spacing. Wider inter-row spacing showed a tendency to improve harvest index, generally. This result was similar with the finding of Amanullah. *et al*.,(2014) who stated that sesame sown with 60 or 50 cm row spacing recorded maximum (16.23 %) harvest index as compared to narrow 30 cm row spacing (15.44 %).

Table 4: Main effect of row spacing and Phosphorus level on biomass and HI

Treatments P(kg ha^{-1})	Biomass(t ha^{-1})	Harvest Index (%)
0	1.97c	21.47
10	2.40b	20.84
20	2.62ba	21.68
30	2.79a	23.38
Inter-row spacing		
30	2.95a	21.89ba
40	2.55b	19.93b
50	2.15c	22.46ba
60	2.13c	23.09a
CV	12.53	16.43

Economic Analysis

Phosphorus level (30kg/ha) and spacings (30cm) inter-row for sesame production was economically beneficial (6640 ETB/ha) and financially profitable (receive 0.273 birr return for every 1 birr investment on sesame production) relative to other treatment combination. To analyse economic benefit of this work partial budget analysis have been employed because partial budgeting is a planning and decision-making framework used to compare the costs and benefits of alternatives faced by a farm business or treatments (Table 5). It includes those resources that will be changed; does not consider the resources in the businesses that are left unchanged (Robert, 2016). Also the to identify financial profitability of each treatment combination rate of return was an analysed based on variable cost incurred and profit gained using the follow formula:

$$RR = \frac{\text{Profit}}{\text{Total variable costs}}$$

As indicated in (Table 8) the result of partial budget analysis revealed that Phosphorus level (30kg/ha) and spacings (30cm) inter-row for sesame production was economically beneficial (6640 ETB/ha) and financially profitable (receive 0.273 birr return for every 1 birr investment on sesame production) relative to other treatment combinations.

RR (0,50) = -0.178 which implies that for this treatment combination producers receive -0.178 birr return for every 1 birr investment on sesame production where producer be at loss. While RR(30,30)= 0.273 implies that for this treatment combination producers receive 0.273 birr return for every 1 birr investment on sesame production

Table 5: Partial budget analysis of effect of P fertilizer and inter-row for sesame production yield

	P*Spacing	Adjusted yield Qt/ha	Total variable cost /ha (ETB birr)	Gross benefit (ETB birr)	Net benefit (ETB birr)	Rate of Return
1	0, 30	5.2	15267	15,600	333	0.021
2	0,40	3.7	13860	11100	-2760	-0.248
3	0,50	3.58	12660	10740	-1920	-0.178
4	0,60	4.43	12393	13290	897	0.067
5	10,30	6.2	16400	18,600	2200	0.112
6	10,40	4.97	14933	14910	-23	-0.001
7	10,50	4.47	13793	13410	-383	-0.028
8	10,60	4.27	13506	12810	-696	-0.054
9	20,30	7.0	16860	21,000	4140	0.197
10	20,40	5.53	15393	16590	1197	0.072
11	20,50	4.92	14193	14760	567	0.038
12	20,60	4.8	13926	14400	474	0.032
13	30,30	8.1	17660	24,300	6640	0.273
14	30,40	6.13	16193	18390	2197	0.119
15	30,50	5.88	14993	17640	2647	0.150
16	30,60	5.9	14726	17700	2974	0.168

Note: Price of UREA=1139 birr Ql-1, price of DAP= 1555.77 birr Ql-1, price sesame seed= 2200birr Ql

4. Conclusion

The 30 cm x 10 cm spacing and 30 kg of Phosphorus level are promising for sesame production under the irrigated condition of the test site and area with similar agro-ecology. However, further study with inclusion of greater Phosphorus levels and narrower inter row spacing could be worthwhile to analyze the response of the crop more and in order to reach at a conclusive recommendation.

Reference

Abdissa Nuressa. 2009. Effect of population density on the yield and yield related characters of Sesame varieties in Gambela, western Ethiopia. An M Sc Thesis, Haramaya University, Haramaya, Ethiopia

Adam L. Ngala, Ibrahim Y. Dugje and Haliru Yakubu.2013. "Effects Of Inter-Row Spacing And Plant Density On Performance Of Sesame (Sesamum Indicum L.) In A Nigerian Sudan Savanna." Sci.Int., 2013: 513-519.

Amanullah Jan, Shahzad Ali, Mohammed Adail and Aziz Khan. "Growth And Yield Components Of Sesame (Sesamum Indicum L)As Influenced By Phosphorus Levels Under." Journal of Environment and Earth Science2014: 150-155

Asif Nadeem1*, Shahabudin Kashani2, Nazeer Ahmed2, Mahmooda Buriro3, Zahid Saeed1,

Fateh Mohammad2, Shafeeque Ahmed2.2015. Growth and Yield of Sesame (*Sesamum indicum* L.) under the Influence of Planting Geometry and Irrigation Regimes. American Journal of Plant Sciences., 6, 980-986

Bachubhai A. Monpara and Devshibhai R. Vaghasia., 2016. Optimizing Sowing Time and Row Spacing for Summer Sesame Growing in Semi-arid Environments of India." International Journal of Current Research and Academic Review, 122-131.

Davut Karaaslan, Erkan Boydak, sinana Gercek and Mehmet SImsek. 2007. Influence of Irrigation Interval and Row Spacing on Some Yield Component os sesame growth in harran region. Asian journal of plant science, vol 6(4), pp, 623-627.

EARO (Ethiopian Agricultural Research Organization), 2004. Directory of released crop varieties & their recommended cultural practices. Addis Ababa

Jakusko B.B, Usman B.D and Mustapha A.B. "effect of row specing on yield and yield component of sesame." journal of agricalture and vetarnery sience, 2013: 36-39.

Langham, D. R., & Wiemers, T. 2002. Progress in mechanizing sesame in the US through breeding. In J. Janick & A. Whipkey (Eds.), Trends in New Crops and New Uses (pp. 157-173). ASHS Press, Alexandria, VA

Miam M.A.K, M.K. Uddin, M.R.Islam, N.A Sultan and Hosna Kohinoor. 2011.crop perfirmance and estimation of the effective level of phospeorus in sesame.academic Journal of plant science, pp 01-05

Muhammad Ibrahima*, Manzoor Hussainb, Ahmad Khanc, Yousaf Jamald, Muhammad Alie, Muhammad Faisal Anwar Malikf.2014 "Effect of Nitrogen and Phosphorus on Yield and Yield Components of Sesame (Sesamumindicum L.)." International Journal of Sciences:Basic and Applied Research, 2014: 95-101

Ö. Öztürk, O. Şaman. "Effects of Different Plant Densities on the Yield." International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering, 2012: 644-649

Robert Tigner, 2016. Making Incremental Farm Business Changes: farm and ranch management series report 1-1

Sevgi Caliskan, Mahmet Arslan, Halis Arioglu and Necmi Isler. "effects of planting method and plant population on growth and yield of sesame in a medetranian type of enviroment." Asian journal of plant science , 2004: 610-613.

Shahab-u-Din K. , Mahmoodah B., Asif N., Nazeer A., Zahid S., Fateh M. and Shafeeque A., 2015. Response of Various Sesame Varieties under the Influence of Nitrogen and Phosphorus Doses. American Journal of Plant Sciences. volume 6 pp 405-412

Smith L. and C. Hamel, 1999. Crop yield; physiology and process. Springer-Verlag, Berlin Heidelberg, Germany