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Effect of Nitrogen Level and Plowing Frequency on Sesame (Sesamum indicum L.) Yield and Yield Component in Western Oromiya, Ethiopia

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Abstract
The field experiment was carried out at Haro Sabu on station, Guliso and Igu kofale location during cropping season of 2014/15 with the objectives of determining the optimum of nitrogen and plowing frequency required for high yield of sesame. The experiment was laid out in RCBD with three replication in factorial combination of six nitrogen level (0, 8, 18, 28, 38, 48kg N ha^{-1}) and three plowing frequency (one, two and three times) on sesame (Dicho) variety. Plant height was significantly ($P < 0.05$) affected by Nitrogen level and highly significantly ($P < 0.01$) affected by plowing frequency. The highest plant height (91.20cm) and (91.18 cm) was recorded from 48 kg N ha^{-1} and three times plowing frequency, respectively. Number of branch per plant was significantly ($P<0.05$) affected by nitrogen level. The highest number of branches per plant (4.40) was obtained from 38kg N^{-ha}. Number of pod per plant was significantly ($P<0.05$) affected by Nitrogen level and Plowing frequency. The highest number of pod per plant (125.79) and (124.57) was recorded from 8kgN^{-ha} and three times plowing frequency, respectively. Grain yield was highly significantly ($P<0.01$) affected by Nitrogen level and plowing frequency. The lowest grain yield (3.40 quintal ha^{-1}) was obtained from 0kg N ha^{-1}. The highest (5.41 quintal ha^{-1}) grain yield was obtained from three time plowing frequency. Partial budget analysis of N fertilizer rates indicted that higher marginal rate of return (1351%) was found by applying 8 kg N ha^{-1}. Therefore Applications of 8 kg ha^{-1} of nitrogen and three times plowing frequency, was recommended for increased yield and better economic returns to sesame growers at study area.
Keywords: Nitrogen level, plowing frequency, Sesamum indicum L.

1. INTRODUCTION

Sesame (*Sesamum indicum* L.) is an ancient oilseed crop, first recorded as a crop in Babylon and Assyria over 4,000 years ago (Weiss, 2000). It is called as "Queen" of oilseeds because of its quality. The crop has then spread from the Fertile Crescent of the Ancient near East to be grown in many parts of the world on over 5 million acres. The biggest area of production in the world is currently believed to be India, but the crop is also grown in China, South Korea, Russia, Turkey, Mexico, South America and several countries in Africa. Ethiopia is a major sesame producing country in Africa next to Nigeria and Egypt (Weiss, 2000).

Bedigian (2003) indicated that the crop is known for high nutritive values of oil or fat (50%) and protein (25%). Panda (2010) reported that the seed contains all essential amino acids and fatty acids and it is the good source of vitamins (Pantothenic acid and vitamin E). The seed also contains important minerals such as calcium (1450 mg/100g) and phosphorus (570 mg/100 g). High quality edible oil can be extracted from the crop, while the remaining cakes serve as valuable source of crude protein for cattle feed, the oil is also used as excellent cooking medium; hence it has high demand on foreign and local market. Sesame seed is used in confectionaries like cakes, cookies and in many other backing products. Minor uses of sesame oil include pharmaceutical and skin care products and are synergist for insecticides. Sesame seed contain 50-60% edible oil and seed cake contain 42% protein rich in tryptophan and methionine which is an excellent feed for milking animals and layers (Hatam and Abbasi 1994). Sesame oil is colorless and odorless, and the presence of antioxidant such as sesamolin, sesamin and sesamol makes the oil highly perceivable as a result of which it does not get rancid (Ahuja *et al.,* 1971).

Nitrogen has been identified as being the most often limiting nutrient in plant growth. It is found to be an essential constituent of metabolically active compounds such as amino acids, protein, enzymes, co-enzymes and some non-portentous compounds (Biswas and Mukherjee, 1993). Plants absorb N in its cationic (NH^{4+}) and anionic form (NO^{3-}). Plants obtain readily available N forms from different sources. Nitrogen fertilizers were essential to increase crop yield, crop quality and production efficiency as nitrogen was the nutrient absorbed in the greatest amounts (Kafkafi and Genbaum, 1971). They also noted that in most crop systems, available nitrogen is often a more limiting factor for plant growth than any other nutrients.

Several investigators reported the positive effects of applying nitrogen fertilization on growth, yield attributes, seed yield and quality of sesame. Osman (1993) reported that grain yield and yield parameters of sesame were significantly enhanced by the application of 40 kg N ha^{-1}. Hossein *et al*. (2007) recorded the highest sesame seed yield with the application of 60 kg N ha^{-1}.

Ploughing systems in addition to establishing a good seedbed are important to reduce weeds. Ploughing is the first step in preparing the land for planting a crop and it is done with the objective of removing the existing vegetation, opening up the soil to aid aeration, water penetration, and soil seed contact (Wrigley, 1981). The first Plowing brings weed seeds to the surface where they can germinate and then be desiccated by additional plowing (Akobundu, 1987).

The farmers in western part of Ethiopia have no information regarding optimum nitrogen and plowing frequency on sesame production. And even they believe that sesame do not prefer fine seed bed and fertilizer application. Also the farmers produce sesame in one time plowing frequency and without application of any fertilizer. Therefore, Sesame production did not give the best returns in terms of yield or cash because of farmers do not consider the appropriate plowing frequency and fertilizer rate. Thus, conducting systematic investigation in this line is very important to come up with relevant recommendation that will help farmers to increase the yield of the crop. Therefore, this experiment was carried out with the objective of determining the optimum N and plowing frequency required for high yield of sesame at western part of Ethiopia

2. MATERIALS AND METHODS

The study was conducted in western Ethiopia, kellem Wollega and western Wollega zones, at Haro Sabu agricultural research center farm, Guliso, and Igu kofale location during cropping season of 2014. The experiment consists of two factor, namely six level of nitrogen (0, 8, 18, 28, 38 and 48 kg ha^{-1}) and three plowing frequency (one, two and three times). Randomized Complete Block Design with three replication in factorial arrangement was used. Dicho variety was used and sown at a rate of 5 kg ha^{-1}. The gross plot area was 6 m^2 (2 m x 3 m) and the net plot area was 3.6 m^2 (1.2 m x 3 m). The plots, which received three plowing frequencies, were plowed first at the beginning of the cropping season; the second one months after the first plowing and the third at sowing. The plots, which received two plowing frequencies, were plowed first at the beginning of the season and at sowing. The plots, which received one plowing, were plowed only at sowing. Nitrogen fertilizer was applied in spilt, half at sowing whereas the remaining half of the N was applied at vegetative stage. The data collected were subjected to Analysis of variance using SAS version 9.0 software (SAS Institute Inc. 2002). Mean separation was carried out using Least Significance Difference (LSD) test at 5% probability level. Variable cost of N fertilizer was used for partial budget analysis**.**

3. RESULT AND DISCUSSION

3.1. Physicochemical Properties of the Soil

Location	Soil class	Organic matter %	Total Nitrogen (%)	Available phosphorous (ppm)	CEC Cmol (+)/kg	pH (1:2.5 H_2O)
Haro sabu on-station	Sandy loam	3.78	0.23	20	20	5.15
Guliso	Sandy loam	3.50	0.25	25	24	5.5
Igu kofale	Sandy loam	5.10	0.20	18	19	5.5

3.2 Phonological and Growth Parameters

Days to flowering and days to maturity was not significantly affected by Nitrogen level, plowing frequency and the interaction effect of Nitrogen level and plowing frequency. However; plant height was significantly affected by Nitrogen level ($P < 0.05$) and highly significantly affected by plowing frequency ($P < 0.01$). As level of Nitrogen application increased from 0 to 46 kg ha^{-1}, plant height significantly increased. “longer plants of 91.2 cm and shorter ones of 81.89 cm were obtained from the highest N rate (48 kg N ha^{-1}) and the control, respectively” (Table 1).This may be due to the fact that nitrogen promotes plant growth, increases the number and length of the internodes which results in progressive increase in plant height. Similar results were reported by Haftamu *et al* (2009) in which higher Teff plant height was found by applying high amount of N fertilizer (92 kg N ha^{-1}).

Three times and once plowing, respectively, have produced longer plants of 90.18cm and relatively shorter plants of 83.83 cm (Table 1). This difference might be due to the fact that more times plowing removes the existing vegetation, opening up the soil to aid aeration, water penetration, and soil seed contact, reduced weeds compete for growth resources (water, nutrient and light). The result of this study was in agreement with Sarder and Rosario (1995) specified that tillage resulted in a higher plant height (14%-20%) than no-till methods in sesame production.Number of branch per plant was significantly ($P<0.05$) affected by nitrogen level while plowing frequency and the interaction effect was not significant. The highest number of branches per plant (4.40) was obtained from 38 kg N ha^{-1}. However, application of 0, 8, 18, 28, 48 N ha^{-1} were not significantly different from each other (Table 1).

Table 1: Effects of nitrogen level and plowing frequency on phenological and growth parameter of sesame at three locations (Guliso, Haro Sabu and Igu location).

Treatment	DF	DM	PH	BRPP
Nitrogen kg ha^{-1}				
0	64.67	127.07	81.89b	3.99ab
8	64.74	127.11	85.89ab	4.10ab
18	64.78	127.07	87.33ab	3.93ab
28	64.59	127.18	87.74a	3.75b
38	64.67	127.22	90.07a	4.40a
48	64.81	127.81	91.20a	3.95ab
LSD (0.05)	NS	NS	5.84	0.59
Plowing frequency				
One times	64.78	127.31	83.83b	3.95
Two times	64.57	127.18	88.04a	3.96
Three times	64.77	127.24	90.18a	4.15
LSD (0.05)	NS	NS	4.13	NS
CV (%)	1.24	1.10	12.42	10.57
NL*PLF	NS	NS	NS	NS

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation; NS =Non Significant; DF=Days to flowering; DM= Days to maturing, PH= Plant height; BRPP = Branch per plant; NL*PLF= interaction of Nitrogen and plowing frequency

3.3. Yield and yield component

Number of pod per plant was significantly (P<0.05) affected by Nitrogen level and Plowing frequency but not the interaction effect of main effect. The highest number of pod per plant (125.79) due to Nitrogen level was recorded from 8 kg N ha^{-1} and not the highest doses (Table 2). This could be because excessive nitrogen has been reported to reduce fruit number and yield for sesame but enhances plant growth (Aliyu *et al*., 1996). This finding was in agreement with those of Bonsu (2003), Fathy and Mohammed (2009).

The highest number of pod per plant (124.57) due to plowing frequency was recorded from three times plowing frequency (Table 2). But one and two times plowing frequency were not significantly different from each other. This might be due to three times plowing frequency making the seed bed finer than one and two times plowing. Because the seeds are so small and the rate of growth during the early phases is so slow, sesame seeds require a seed bed with firm, fine crumbs and sufficient moisture, in order to ensure their rapid, uniform germination and subsequent growth. This finding was in agreement with (Bulent *et al*, 2012) who reported that the highest pod per plant was obtained from conventional tillage methods than those of no-till.

Analysis of variance showed a significant (P<0.01) variation in grain yield due to the effect of Nitrogen level and plowing frequency, while the interaction effect was not significant. Application of 8, 18, 28, 38 and 48kg N ha^{-1} were not significantly different from each other but significantly different from 0 kg N ha^{-1}. The lowest grain yield (3.40 quintal ha^{-1}) was obtained from 0 kg N ha^{-1} (Table 2). The response of grain yield of sesame to nitrogen application may be due to the beneficial role of nitrogen on stimulating plant growth. It might also be due to more accumulation of nitrogenous substances and their translocation to reproductive organs or due to efficient seed filling as a result of photosynthates translocation finally improving the seeds weight. These results are in agreement with Jadhav *et al. 1991.*

The highest (5.41 quintal) grain yield was obtained from three times plowing and the lowest (3.76 quintal) was obtained from one times plowing (Table 2). This may be due to three times plowing frequency favoring better root growth and nutrient uptake by the crop and hence positive physiological and metabolic activities. Plowing practice favorably influences the soil-water-plant ecosystem, thereby affecting crop yields and quality. One times plowing may restrict root growth resulting in poor above ground plant growth as the nutrient uptake by the plant is reduced. The ultimate result is the reduction of grain yield and in contrast, frequent tillage significantly increased grain yield.

Table 2: Effects of Nitrogen level and plowing frequency on yield and yield component of sesame at three locations (Guliso, Haro Sabu and Igu location)

Treatment	Pod per plant	Yield in quintal ha^{-1}
Nitrogen kg ha^{-1}		
0	114.09Ab	3.40b
8	125.79a	5.06a
18	109.81ab	4.83a
28	103.77ab	4.72a
38	117.37ab	5.19a
48	94.78b	4.99a
LSD (0.05)	27.15	0.61
Plowing frequency		
One times	101.49b	3.76c
Two times	106.74b	4.91b
Three times	124.57a	5.41a
LSD (0.05)	19.20	0.43
CV (%)	11.48	8.43
PLF*NL	NS	NS

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation; NS =Non Significant; NL*PLF= interaction of Nitrogen and plowing frequency

3.4 Partial Budget Analysis of Nitrogen Fertilizer rate

The economic assessments were made using partial budget analysis as described by CIMMYT (1988).The economic analysis indicates that high marginal rate of return (1560%) was obtained by applying 8 kg N ha^{-1} (Table 3). This means applying 8 kg N/ha for sesame was given 15.60 Ethiopian birr for ever invested one birr.

Table .3 Partial budget analyses for nitrogen fertilizer Total cost and total income	**N-fertilizer rates (N)**					
	0kgN/ha	8kgN/ha	18kgN/ha	28kg N/ha	38kgN/ha	48kg N/ha
Cost						
1. Labor cost						
• Fertilizer application		40	40	40	40	40
2. Fertilizer cost		226	508	791	1073	1356
Total cost		266	548	831	1113	1396
Income						
Economic (grain) yield (kg/ha)	340	506	483	472	519	499
Income (birr/ha)	8500	12650	12075	11800	12975	12475
Change in cost (ΔC)		266	548	831	1113	1396
Change in income (ΔI)		4150	3575	3300	4475	3975
Marginal Rate of Return (MRR = (ΔI)/(ΔC)*100)	0.00	1560%	652%	397%	402%	284%

Where,
1. ΔC = cost of each rate subtracted from cost of the control the
2. ΔI = income of each rate (Birr/ha) subtracted from the income of control
3. Labor costs were calculated by assuming 20 birr/labor/day
4. Incomes were calculated by assuming 2500birr/100kg of sesame.

4. CONCLUSIONS AND RECOMMENDATIONS

Nitrogen has been identified as being the most often limiting nutrient in plant growth. It is found to be an essential constituent of metabolically active compounds such as amino acids, protein, enzymes, co-enzymes and some non-proteins. Applying nitrogen fertilization has a positive effect on growth, yield attributes, seed yield and quality of sesame. Ploughing systems in addition to establishing a good seedbed are important to reduce weeds. Ploughing is the first step in preparing the land for planting a crop and it is done with the objective of removing the existing vegetation, opening up the soil to aid aeration, water penetration, and soil seed contact.

In view of this, the experiment was conducted in 2014 cropping season at Guliso, Haro Sabu and Igu sites to determine the effect of Nitrogen level and plowing frequency on yield and yield component of sesame.

The result indicated that Days to flowering and days to maturity was not significantly affected by

Nitrogen level, plowing frequency and the interaction effect of Nitrogen level and plowing frequency. However; plant height was significantly ($P < 0.05$) affected by Nitrogen level and highly significantly ($P < 0.01$) affected by plowing frequency .The highest plant height (91.20cm) was recorded from 48kg N-ha while the lowest plant height (81.89cm) was obtained from zero Nitrogen application (control). The highest plant height (91.18cm) and the lowest plant height (83.83cm) due to plowing frequency was recorded from three times and one times plowing frequency, respectively. Number of branch per plant was significantly ($P<0.05$) affected by nitrogen level wile plowing frequency and the interaction effect was not significant. The highest number of branches per plant (4.40) was obtained from 38kg N ha^{-1}.

Number of pod per plant was significantly ($P<0.05$) affected by Nitrogen level and Plowing frequency but not the interaction effect of main effect. The highest number of pod per plant (125.79) due to Nitrogen level was recorded from 8 kg N ha^{-1}. The highest number of pods per plant (124.57) due to plowing frequency was recorded from three times plowing frequency.

Analysis of variance showed a significant ($P<0.01$) variation in grain yield due to the effect of Nitrogen level and plowing frequency, while the interaction effect was not significant. The lowest grain yield (3.40 quintal -ha) was obtained from 0kg N-ha. The highest (5.41 quintal) grain yield was obtained from three time plowing and the lowest (3.76 quintal) grain yield was obtained from one times plowing. The partial budget analysis indicates that high marginal rate of return (1560%) was obtained by applying 8kg N/ha. Therefore Applications of 8 kg ha^{-1} of nitrogen and three times plowing frequency, was recommended for increased yield and better economic returns to sesame growers at study area.

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