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Effect of Fertilizer Rate on the Yield And Yield Component of Sesame(*Sesamumindicum*) in Moisture Stress of Eastern Harerghe Zone

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Abstract

Field trials on sesame were conducted at the Fadis Agricultural Research Station during the 2014 and 2015 cropping seasons to determine the optimal rate of Nitrogen(UREA) fertilizer and Phosphorus(DAP) for sesame production. The experiment consisted of four rates of Nitrogen in the form of UREA (0, 40, 60, &80kg ha^{-1}), and four levels of Phosphorus in the form of DAP (0, 10,20&30kg ha^{-1}) applied to the treatments. The sixteen treatment combinations were laid out in a RCBD design with three replications. Yield of Sesame and yield related components were showing significant difference ($p<0.05$). Analysis of variances showed that grain yield, number of capsule per plant, number of seeds per capsule and number of branching per plant was significant differences at ($P<0.05$) both at Fadis and Erer of study areas. Grain yield increases from 518.1kg/ha to 891kg/ha as N increases from 0(control) to 24.6kgN (60kgDAP @ 30kgUREA).

Keywords: Nitrogen; Phosphorus; Plant nutrient; Sesame

Introduction

Sesame (*Sesamumindicum*) is grown in areas with annual rainfall of 625-1100mm and temperature of >27 °C. The crop is tolerant to drought, but not to water logging and excessive rainfall [1].

In Ethiopia, the production of sesame is both by small and large scale farmers; and it is an important crop and export commodity. The total area, production and productivity during 2013 were 0.299 million ha, 0.220 million tones and 0.735 t ha^{-1}, respectively; and the total area and production were increased by 61.23% and 17.91%, respectively, while the total productivity was decreased by 27.23% when compared with in 2008 [2,3]. Sesame ranks first in total area and production from oil crops during 2013; and Tigray, Oromia, Amhara and BenshangulGumuz regions are the major producers in Ethiopia.

Since sesame contributes more than 80% of the export earning of oil seeds it has become the 2nd foreign currency earning crop after coffee. Ethiopian sesame seed market covers quiet a wide range of countries all over the world. The growing demand in the world market and the available capacity to expand sesame production could contribute to the economic growth of Ethiopia .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 [4]. The major sesame seed producing regions are situated in the North West and South West Ethiopian in Humera, North Gondar and Wollega [2,5]. For instance, the main source of farmers' income in western Tigray was sesame sales.

Sesame is deep rooted and will scavenge for fertility below the wheat root zone, but that only works once. The sesame will strip that lower reserve, and the fertility will not be available for future sesame crops. The rates vary with soils, rainfall patterns, and local farming practices. There is little work on PK rates and most farmers use the cotton recommendations for their soils [6]. Work has shown that N P is critical for high yields, particularly in acidic soils. When having to apply all of the fertility up front, a slow releasing fertilizer should be used. Using a full rate of anhydrous ammonia up front has not worked because it is not available at the critical time when the plants are producing seeds.

At present, the Ethiopian government devotes considerable resources to research and extension in view of encouraging small

scale farmers to increase their productivity and to be focused them on international high market demanded crops to increase export earnings of the country. One of such crop is improved sesame. Sesame is one of the oil crops grown in the area next to groundnut in the study areas. In the last year (the second year cropping the study) Participatory Agricultural Production Constraint Analysis survey was taken and they underline the constraints based on the assessment taken in description of AGP-II districts in the study areas. Farmers from the assessment description of AGP-II districts noted that poor soil fertility is the number one of production constraints in the area.

The major constraints in sesame production worldwide are lack of wider adapting cultivars, shattering of capsules at maturity, nonsynchronous maturity, poor stand establishment, lack of fertilizer responses, profuse branching, and low harvest index [7]. Thus this experiment was aimed to solve the response of fertilizer rate for sesame in moisture stress of eastern hararghe (Table 1- 3).

Table 1: The mean of sesame yield and yield component parameters at Fadis and Erer 2014 production year.

Treatment Name	Grain Yield and Yield Component at Fadis				Grain Yield and Yield Component at Fadis			
	Grain Yield Kg/Ha	No Branches /Plant	Pod /Plant	Seed/Pod	Grain Yield/ Kg	No Branches /Plant	Pod/Plant	Seed/Pod
0DAP@0UREA	525c	14.33cd	57.67	31.67	616.7c	15.00bc	56.33ab	28.67
0DAP@10UREA	680.6bc	17.67bcd	66.33	34	720.8bc	21.67ab	55.67ab	31
0DAP@20UREA	628.9bc	18.33bcd	47.33	33	763.9bc	19.33ab	44.67b	30
0DAP@30UREA	522.2c	16.67abc	57	32.33	648.6c	20.67ab	6.00ab	29.33
40DAP@0UREA	759.7ab	12.67cd	58	33.33	754.2bc	16.67bc	67.33a	30.33
40DAP@10UREA	754.4ab	11.33cd	56.67	31.67	697.2bc	15.33bc	55.67ab	28.67
40DAP@20UREA	731.9abc	23.33ab	56.67	32.67	847.2b	20.00abc	55.67ab	29.67
40DAP@30UREA	641.7bc	11.67cd	57	33	625.0c	15.67bc	56.33ab	30
60DAP@0UREA	709.4abc	8.67d	67	32.33	679.2bc	16.67bc	56.00ab	29.33
60DAP@10UREA	794.2ab	18.33bcd	57	32	630.6c	18.33bc	56.67ab	29
60DAP@20UREA	759.7ab	12.67cd	56.67	33	675.0bc	16.67bc	55.67ab	30
60DAP@30UREA	867.8a	18.33a	67.33	31.67	912.5a	22.33a	56.00ab	28.67
80DAP@0UREA	610.8bc	13.33abcd	67.33	32.67	673.6bc	17.33bc	67.00a	29.67
80DAP@10UREA	686.1abc	12.33abcd	56.67	32.67	683.3bc	16.33bc	56.00ab	29.67
80DAP@20UREA	697.2abc	9bcd	57	32.67	691.7bc	13c	44.67b	29.67
80DAP@30UREA	818.1ab	8bcd	57	33.67	677.8bc	12c	55.67ab	30.67
CV (%)	15.4	11.4	12.3	4.4	18.8	10.9	19.9	4.9
L.S.D	181.34	5	Ns	ns	162.53	4.96	11.94	Ns
P Value	*	*			*	*	*	

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Table 2: The effect fertilizer rate on sesame yield and yield component at Fadisand Erer in 2015.

Treatment Name	Grain Yield and Yield Component at Fadis				Grain Yield and Yield Component at Erer			
	Grain Yield/Kg	No Branches /Plant	Pod /Plant	Seed/Pod	Grain Yield/Kg	No Branches/ Plant	Pod/Plant	Seed/Pod
0DAP@0UREA	598.6b	7.47bc	65.5bc	44.33b	652.5d	5.67c	69.67ab	46
0DAP@10UREA	664.4b	6.00c	56.00c	53.00ab	746.1c	6.33c	64.33ab	42
0DAP@20UREA	715ab	6.33c	56.33c	44.00b	772.2bc	6.33c	62.33ab	45.33
0DAP@30UREA	650.8b	4.33c	49.33c	54.00ab	702.8c	6.00c	61.00ab	44
40DAP@0UREA	700.6b	5.83bc	59.83bc	55.67ab	756.9c	7.67b	73.67ab	44.67
40DAP@10UREA	886.7ab	6.5bc	87.17ab	53.67ab	748.9c	7.00b	72.00ab	44.67
40DAP@20UREA	865.3ab	7.53b	89.83ab	57.00ab	807.5ab	7.33b	71.33ab	46.67
40DAP@30UREA	804.2ab	6.83c	56.83c	44.33b	799.7b	6.67b	62.67ab	44
60DAP@0UREA	723.6b	5.17bc	67.67abc	59.33a	727.8b	6.33c	62.33ab	44.67
60DAP@10UREA	938.9a	6.33bc	60.33bc	55.67ab	760.6c	9.00a	69.00ab	46.67
60DAP@20UREA	741.1ab	12.43ab	59.17bc	49.33ab	780.0b	7.67b	59.67b	44
60DAP@30UREA	964.2a	15.17a	96.43a	61.00ab	897.2a	9.67a	74.67a	44
80DAP@0UREA	898.6ab	5.33c	50.33c	53.67ab	653.6d	6.67b	64.67ab	46
80DAP@10UREA	672.5ab	7.00bc	75.00abc	48.33ab	643.9d	5.67c	59.67b	44
80DAP@20UREA	891.4ab	5.17c	52.17c	49.67ab	774.2bc	6.00c	66.00ab	45.33
80DAP@30UREA	842.8ab	6.50bc	65.50bc	47.00ab	646.1d	7.33b	74.33a	43.33
CV (%)	19.1	25.8	25.8	13.1	16.7	7.3	7.3	6.4
L.S.D	269.7	7.6	27.6	11.42	170.68	1.33	11.7	ns

Table 3: The overall mean interaction of sesame yield of the two locations (Erer and Fadis) in 2014 & 2015.

Treatment Name	Grain Yield/Kg	No Branches/Plant	Pod/Plant	Seed/Pod
0DAP@0UREA	518.1d	20b	48.21b	41.58
0DAP@10UREA	703bc	17.42b	58.21ab	40
0DAP@20UREA	670bc	17.33b	57.50ab	38.08
0DAP@30UREA	651.6bc	19.42b	57.75ab	39.92
40DAP@0UREA	692.8bc	15.71b	57.83ab	41
40DAP@10UREA	696.9bc	19.21b	57.46ab	39.67
40DAP@20UREA	763b	23.62a	57.04b	41.5
40DAP@30UREA	617.6cd	14.21c	57.67ab	37.83
60DAP@0UREA	617.7cd	15.02c	58.00ab	41.42
60DAP@10UREA	652.2bc	20b	58.58ab	40.83
60DAP@20UREA	639c	14.54c	58.21ab	39.08
60DAP@30UREA	891a	28.71a	68.67a	38.83
80DAP@0UREA	659.2bc	18.92b	58.54ab	40.5
80DAP@10UREA	614cd	13.33c	58.33ab	38.67
80DAP@20UREA	663.6bc	17.54b	57.58ab	39.33
80DAP@30UREA	693.7bc	12.46c	58.17ab	38.67
CV (%)	18.3	13.6	19.8	9.6
L.S.D	126	3.62	11.28	ns

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Materials and Methods

Description of experimental site

The study was conducted under rain fed conditions at two location (Fadis; Boko site) and Erer sub-site. Fadis, is located at the latitude of 9º 07' north and longitude of 42º 04' east, in the middle and lowland areas and at the altitude of 1702 meters above sea level, with a prevalence of lowlands. The area is situated at the distance of about 24km from Harar town in the southerly direction. The experimental area is characterized as lowland climate. The mean rainfall is about 860.4 mm for the last five years. The rainfall has a bimodal distribution pattern with heavy rains from April to June and long and erratic rains from August to October. The mean maximum and minimum annual temperature are 28.2 °C and10.2 °C, respectively, for the last five years (Fadis Agriculture Research Center Metrological Station) (Appendix. 1 & 2).

Appendix 1: Eight (8) years precipitation (Rain fall) mm data.

Months	Years							
	2009	2010	2011	2012	2013	2014	2015	2016
January	0	0	0	0	16.8	0	25.5	4.7
February	72.1	61.5	9.4	0	0	1.2	4.9	0
March	23.4	223.5	3.2	4.4	190.3	95.6	66.0	26.4
April	111.5	187.1	25.7	190.6	147.2	108.7	29.6	239.5
May	145.2	199.5	226.0	124.5	60.6	117.7	161.7	170.55
June	68.8	22.5	67.7	69.4	46.3	67.5	132.3	94.8
July	112.2	122.1	60.8	95.9	96.6	66.5	44.9	96.3
August	109.3	119.7	144.4	164.9	59.3	201.4	106.3	56.8
September	115.8	136.9	224.9	220.25	126.4	94.1	95.5	100.0
October	183.5	11.4	3.4	3.9	116.3	166.5	25.2	36.3
November	13.8	18.7	25.5	0.6	66.7	17.9	22.4	48.7
December	0.9	0	0	2.7	0	0	10.6	9.7

Appendix 2: Average of 8 years mean of maximum temperature of Fadis (°C).

Months	Years															
	2009		2010		2011		2012		2013		2014		2015		2016	
January	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
	28.2	11.1	27.9	11.3	28.5	8.4	28.6	8.2	28.9	7.1	28.8	5.8	28.5	6.3	28.9	9.4
February	27.8	12.1	28.0	13.6	30.0	9.3	31.0	7.2	31.0	7.1	30.1	8.3	31.4	6.5	31.5	8.6
March	28.1	12.4	27.3	13.5	30.8	10.5	29.4	9.3	29.4	9.8	30.3	9.5	31.4	8.7	33.6	11.4
April	27.9	13.3	27.2	14.2	31.0	12.5	27.6	11.4	28.0	11.2	28.4	10.6	31.6	9.6	28.5	12.2
May	27.3	13.8	27.4	15.0	27.5	12.0	27.8	11.1	28.0	10.3	27.5	10.6	29.2	10.6	28.0	11.3
June	28.7	13.7	27.0	14.5	26.3	12.5	27.2	10.4	27.5	10.2	28.9	9.8	28.4	10.8	27.2	10.6
July	27.8	13.9	24.6	12.3	26.0	11.8	25.2	10.9	24.8	10.2	28.6	10.3	28.3	10.3	26.9	10.9
August	28.7	14.3	25.5	12.9	25.7	12.0	26.7	10.2	26.3	9.9	27.5	9.7	28.1	10.6	27.3	11.0
September	27.8	14.0	26.6	12.0	25.9	11.2	26.5	10.3	27.9	9.2	26.8	9.7	29.7	10.4	28.8	10.7
October	26.9	15.8	28.6	9.8	28.5	8.2	27.9	6.9	27.8	8.3	27.4	7.8	30.9	9.4	28.9	10.0
November	27.8	10.3	27.7	9.1	28.1	8.8	28.8	6.9	27.2	7.3	28.5	7.1	30.0	8.7	29.2	8.2
December	27.3	11.9	27.3	7.5	27.1	7.0	29.7	6.5	26.9	4.9	27.8	5.6	29.3	8.8	29.1	7.9

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The second experimental area of our experiment Erer Sub-site is located at Erer valley of Babile Wored as, which is located at 34km from Harar city in eastern direction. The area receives an average annual rainfall of about 400 - 600mm. The altitude of the area lay between 950- 2000 meters at sea level. And the experimental area was extremely lowland which is suitable for the production of sesame.

Data to be collected

All quantitative data (number of branches per plant, number of capsule per plant, number of seed per capsule, seed yield per hectare (kg/ha)) were collected.

Data management and statistical analysis

The experimental plots were laid out in Randomized Complete Block Design (RCBD) with three replications.

The treatments were inserted randomly to each block. All collected data were entered into computer and analyzed using GenSTAT statistical software package and mean values or Least Significant Differences (LSD) were compared using the procedures of Duncan's at the 5% level of significance.

Description of experimental materials

This experiment were planted at Fadis station and Erer sub-site with main objectives of evaluating, identifying and, recommending the best fertilizer rate that maximum yield with the best performance of sesame at lowland and mid-altitude of Eastern Harerghe area.The treatments consisted of a sesame variety (Tate), four nitrogen levels (0, 10, 20 and 30kgN/ha) in the form of UREA and four phosphorus levels ((0, 40, 60 and 80kg) P2O5/ha) in the form of DAP. The treatments were arranged in a Randomized complete block design with three replications. The experimental field was ploughed, harrowed and ridged 40cm apart. A mixture of one part of sesame Seed and two parts of course river sand were sown manually at a shallow depth of about 1cm, by dibbling. The emerged plants were thinned to one plant per stand at two weeks after sowing at an intra-row spacing of 10cm. This arrangement gave population densities of 250,000 plants per hectare. Phosphorus fertilizer was applied at planting to all the plots at the rate of 0kg, 40kg, 60kg and 80kg in the form of DAP. Nitrogen fertilizer was applied at two and six weeks after sowing in two equal split doses at the rates of ((0kg, 10kg, 20kg and 30kg)N/ha) as per treatments using Urea (46%N). All agronomic practices were equally applied as per recommended.

Experimental Procedures

The experimental field was cultivated to a depth of 25- 30cm by a tractor. The experimental plots were harrowed to a fine tilth manually before planting. The land was leveled well. Seeds were sown on well prepared experimental plot on 28June 2014 and 27 June 2015 of cropping season. Sesame seeds were carefully sown at 1cm depth in the prepared plots with 4.2mx3m dimensions to accommodate 180 plants per plot at a recommended spacing of 40cmx10cm between rows and plants, respectively. Standard agronomic practices such as weeding, cultivation, fertilizer application (accordingly the rate of treatments) and tinning were carried out uniformly during the growing season for all plots. Starting from land preparation to harvesting and storing the seeds carefully attention was given accordingly to follow the all data collection; recording and registering (entering) in to computer were done appropriately.

Results and Discussion

The experiment was conducted at two locations (Fadis station and Erer sub-station) for two years (2014 & 2015) with theobjective of evaluating the effect of fertilizer rate on the yield and yield component of sesame (Tate) [8]. Showed that different levels of nitrogen and phosphorus significantly ($P<0.05$) affected almost all the growth and yield attributes of sesame varieties, particularly seed yield. Maximum plant height (cm), branches plant-1, capsules plant-1, seeds capsule-1, seed weight plant-1 (g), seed index (1000 seed weight, g) and seed yield (774.17kg. ha^{-1}) were recorded in NP @ 70-70kg·ha^{-1}, followedby NP @ 70-50kg.ha^{-1}, whereas minimum growth and yield parameters were noted in No fertilizer (Control). Similarly in our findings application of NP rates show significant effect ($P\leq0.05$) on number of branching per plant, number of capsule per plants, number of seeds per capsule and grain yield at harvesting time during 2014 at Fadis and Erer (Table 1). The number of branching per plant increased from 14.33 to 18.33 as the application of fertilizer increased from 0kg (control) to 24.6kg (60DAP@30UREA) of nitrogen and number of branching decreases as N rate increases. As N rate increases the plant were elongated rather than branching. In 2015, similarly significant difference ($P\leq0.05$) was observed on number of primary branches per plant because of application of Nitrogen and Phosphorus. At both location (Fadis station and Erer sub-station) there were significant difference on grain yield. But the yield obtained was quite far for the location. This might be influenced by the environment which could have counted for the fewer branches in sown crops because of the change in the environmental condition that forces the crop to reduce vegetative growth and commence reproductive phase as reported by [9]. In 2015 because of the occurrence of El-Nino the eastern parts of Ethiopia is highly affected. Thus why the experimental plot is also affected. Branching in crops has been reported by [10] to be enhanced by favorable growth condition as obtained in most cases at early part of the season when rains are fully established.

[11] reported that Interaction between nitrogen and phosphorus showed maximum number of pods/plant (70) at 100:80kg N: P/ha, while minimum number of pods/plant (48) was recorded at 40:40kg N: P/ha. The lowest number of pods/plant (35) was recorded in control plot. Similarly in the study areas the number of capsule increases as Nitrogen and Phosphorus increases from 0kg of DAP and UREA (control) to 60kg of DAP and 30kg of UREA.

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Analysis of variances showed that grain yield, and number of branching per plant was significant differences at (P<0.05) both at Fadis station and Erersub-station in 2014. Grain yield increases from 525kg/ha to 867.8kg/ha as Nitrogen increases from 0 to 24.6kgN(60kgDAP and 30kgUREA) at Fadis and similarly at Erer grain yield increases from 616.7kg/ha to 912.5kg/ha as Nitrogen increases from 0 to 24.6kgN(60kgDAP and 30kgUREA).This foundation is agreed with the ideas of [12] that indicates maximum yield of seed hectare-1(1.26t) was obtained from N1 (60kg/ha) whereas the minimum yield of seed per hectare (0.88t) was obtained from N0 (control or without N). N1 (60kg/ha) gave the maximum yield than N2 (120kg/ha) this could be because of excessive nitrogen had been reported to reduce fruit number and yield for sesame but enhances plant growth [13]. As NP increases above the Optimum rate the plant was elongated rather than fruiting and branching. Similarly significant difference was observed on number of branching as Nitrogen and Phosphorus rate increases from 0 to its optimum rate and then decreases above optimum rate because the crop was elongated rather than branching. From the two year (2014 and 2015) and two locations (Fadis and Erer) data; analysis of the variance shows that there was significant difference statically among the treatments because of the application of Nitrogen and Phosphorus rates. Some research findings indicate that sesame cannot respond to fertilizer [10] reported that Number of seeds per pod was similar in the pots that received N fertilizer and those that did not and also he reported that Number of branches per plants, number of seed per pod, seed yield and dry matter yield were not significantly influenced by Nitrogen fertilizer application.

In the contrast of the above statement from the study areas application of NP to sesame have significant differences among the treatments. Fertilizer studies on sesame, in Ethiopia, are highly limited in scope covering a small proportion of the sesame growing areas in the country. The result of these limited research activities suggested that sesame did not respond to fertilizer addition. But the very recent studies at Bako Agricultural Research Center indicate 35% yield increment due to application of 38/29 kg/ha NP_2O_5 fertilizers at planting [6]. In the study areas of our finding yield increment were observed on the plot that received 24.6kg/ha of nitrogen and 27.6kg/ha of phosphorus or (60/30kg/ha NP_2O_5). But some research findings reveal that significance difference was observed by the application NP. [18] reported that grain yield and yield parameters of sesame were significantly enhanced by the application of 40kg N ha^{-1} [14]. Showed that phosphorous application at the rate of 22kg P ha-1 significantly enhanced seed yield, seed oil content and seed protein content of sesame [15] found that application of 60kg N ha^{-1} and 13.2kg P ha^{-1} produced significantly the highest number of capsules per plant, branches per plant, capsule weight per plant and grain yield per hectare [16]. Recorded the highest sesame seed yield with the application of 60kg N ha^{-1} [17] found that application of 75kg N ha^{-1} and 26.4kg P ha^{-1} significantly increased the number of seeds per capsule and seed yield per hectare.

Number of pods/plant

Analysis of variance showed that number of pods/plant was significantly affected by different levels of nitrogen and phosphorus, while interaction between nitrogen and phosphorus was also found significant. Mean values for nitrogen revealed that maximum numbers of pods/plant (68.67) was noted at 40/10kg/ha NP_2O_5 and minimum number of pods/plant (48.21) was noted at 0kg/ha NP_2O_5 (control). Number of pods/plant increased with increase in phosphorus levels and minimum number of pods/plant (48.21) was noted at 0kg P_2O_5/ha. The Interaction between nitrogen and phosphorus showed maximum number of pods/plant (68.67) at 40:10kg P_2O_5: N/ha, while minimum number of pods/plant (48.21) was recorded at 0:0 kg N: P_2O_5/ha which is lowest number of pods/plant and recorded in control plot.

Grain yield kg/ha

Sesame grain yield increased significantly with increase in the rate of nitrogen fertilization, implying that sesame yields could be boosted through an increase in nitrogen fertilizer application [18]. The grain yield of sesame plot-1 (g) was converted into hectare-1 and has been expressed in kilo grams. The different levels of nitrogen had significant effect on the yield of seed kilo grams (kg) hectare-1. The maximum yield of seed hectare-1(891kg) was obtained from T2 (24.6kg/ha N) or (60DAP@30UREA) whereas the minimum yield of seed per hectare (518.1kg) was obtained from T1 (control or without N). T7 (16.4 kg/ha N) gave the maximum yield than T14 (19 kg/ha N) this could be because of excessive nitrogen had been reported to reduce fruit number and yield for sesame but enhances plant growth [12]. Similarly this finding agreed with the report of [9] that indicates the highest seed yield (750.4kg ha^{-1}) was recorded from the interaction level of 60-30NPkg ha-1 and 5t ha^{-1} FYM, and the lowest seed yield (480.6kg ha^{-1}) was recorded from zero level of NP and FYM main factors [18-24].

Conclusion

In any case before application of fertilizers consider the growth stage of the plant; population; and amount of soil moisture available. Fertilizer applications should be based on soil test results. Since sesame is exported crop most investors are engaged in production and exporting of the commodity in Ethiopia. Now a day because of low quantity of the crop they are diverting to other commodity rather than Sesame. So emphasis should be given for the crop in order to increase the quantity and quality of the commodity through breeding and other agronomic practices. Then research work have incredible role in increasing both the quantity and quality of sesame.

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