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Effect of NPS and Nitrogen Fertilizers on Growth, Yield and Yield Components of Linseed (*Linum usitatissimum L.*) at Western Oromia, Ethiopia

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Abstract: The study was conducted at Chaliya district Chobi Tulu Chori kebele and Horo District Gitilo Dole Kebele during 2018 and 2019 main cropping season to identify optimum agronomic and economic threshold of NPS and Nitrogen fertilizers. The experiment consisted of two factors (0, 25, 50, 75 and 100 kg ha^{-1} NPS rates) and (0, 23, 46 and 69 kg ha^{-1} Nitrogen rates). A total of 20 treatments were laid out in Randomized Complete Block Design with three replications in 5x4 factorial arrangement. The results indicated that primary branch, capsule per plant, above ground dry biomass and yield were significantly affected by the main effect of NPS and nitrogen fertilizers. The highest grain yield (1400kg and 1382 kg ha^{-1}) were obtained from the application of 25 kg NPS + 69 N kg ha^{-1} and 25 kg NPS + 46 kg ha^{-1} N fertilizers respectively. The lowest grain yield (520 kg ha^{-1}) was recorded from the control treatment (0 kg NPS + 0 kg ha^{-1} N fertilizers). This indicates that 62.86% yield reduction was recorded as compared to the application of 25 kg NPS ha^{-1} + 69 kg N ha^{-1} fertilizer. The highest net benefit (35389ETB) and acceptable marginal rate of return (2038%) were obtained from the application of 25 kg NPS ha^{-1} + 46 kg N ha^{-1}. Therefore application of 25 kg NPS + 46 kg N ha^{-1} fertilizer rates was recommended for production of linseed in the study areas and similar agroecology.

Keywords: Fertilizer, Linseed, Marginal Rate of Return, Net Benefit

1. Introduction

Linseed, (*Linum usitatissimum L.*) (n=15), is an important oilseed crop which belongs to the family linaceae having 14 genera and over 200 species. It is one of the oldest crops known to man and it has been cultivated for fiber and seed oil. Originated from Europe and Southern Asia [1]. It is thought to have been an early introduction to Ethiopia [2]. The oil, which is approximately found in the rate of 35-46% in the linseed [3].

Nitrogen is often the most important plant nutrients, which affect the amount of protein, protoplasm and chlorophyll formed, consequently increases cell size, leaf area and photosynthetic activity. The reaction of linseed to nitrogen has been well established, as has the sensitivity of crop emergence and seed yield to seed-placed nitrogen [4, 5] also reported that nitrogen levels affect plant height, number of capsules/plant, 1000-seed weight and seed yield ha^{-1}.

Phosphorus fertilizer is critical for plant growth and yield of linseed. [6] reported that mean performances of linseed differed for seed and straw yields with the application of phosphorus fertilizer [4] stated that linseed response to phosphorus fertilizer addition is highly variable, supporting the importance of maintaining medium to high soil P levels to optimize linseed yields. [7] reported that Phosphorus did not significantly increase the yield. [8] concluded that to optimize crop nutrition, phosphorus must be available to the crop in adequate amounts during the growing season

Ethiopia is one the 5th major producer of linseed in the world after Canada, China, USA and India. In Africa Ethiopia is the first producers. Which is mainly produced in central highland of the nation [9]. Linseed has a long history of cultivation by smallholder farmers and the second most important oil crops next to Noug, exclusively for its oil in the traditional agriculture of Ethiopia [9]. About 25% of the total land allocated for oil crop production in Oromia region was covered by linseed [10]). Even though the production area of linseed is the second largest next to Noug, its productivity is still low as compared to its potential productivity.

The reason why the productivity is low in Ethiopia is due to lack of high yielder variety, poor agronomic practice special application of inorganic fertilizer is very low. Because the perspective of farmers is low about the importance of inorganic fertilizer for linseed production and therefore; farmers produce linseed without or little application of fertilizer.

For the long period of time in Ethiopia agriculture system the farmer use only di-ammonium phosphate and Urea. But recently Ethiopian soil information system (EthioSIS) develop soil map based on soil fertility. Accordingly in the study areas soil was deficiency in sulfur in addition to nitrogen and phosphorus. To overcome this problem recently Ministry of Agriculture of the country introduced a new fertilizer (NPS) containing nitrogen, 19% phosphorous 38% and sulfur 7%. Therefore, this research was developed with the objective of;

to determinate the optimum agronomic and economic threshold of NPS and Nitrogen fertilizers.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted at Chaliya district, Chobi Tulu Chori kebele and Horo District, Gitilo Dole Kebele for two consecutive years (2018 and 2019). Chobi Tullu Chori kebel is located between 9°0’00”N to 9°3’30”N, 37°32’00”E to 37°8’00”E and its altitude 2450m and Gitilo Dole kebele is located between 9°30’30”N to 9°34’30”N, 37°0’30”E to 37°8’00”E and its altitude 2800m (Figure 1). Both locations receive a mono modal pattern of rainfall distribution that receives from May to September and the soil of the areas is reddish. Wheat, Barley, Faba bean, Field bean, Linseed and Noug are the major crops that are commonly grown in the area.

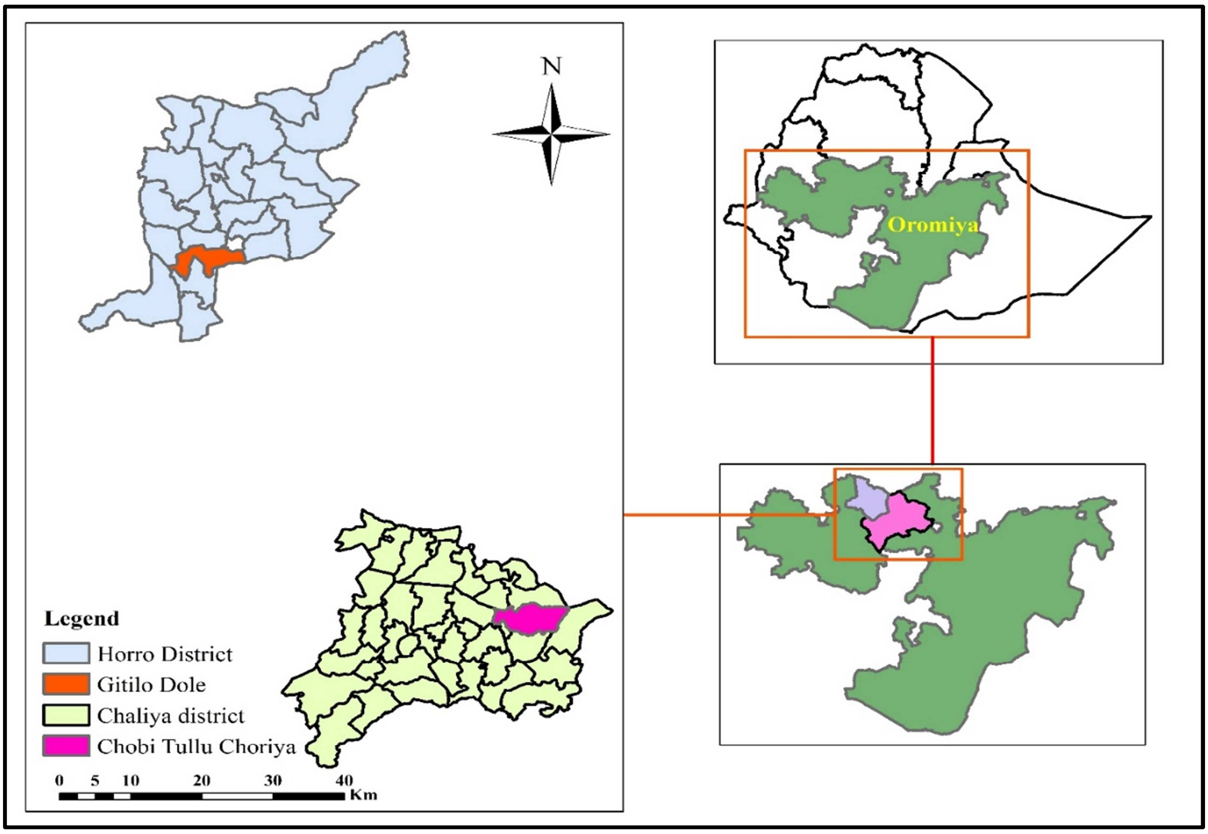

Figure 1. *Map of the study area.*

Table 1. *Physico-chemical properties of experimental soil before planting.*

Soil characteristic	Value		
	Chobi Tulu Chori	Gitilo Dole	Description
Textural class	Clay loam	Clay loam	
pH (1:2.5 H2O)	5.02	5.07	acidic
Organic matter (%)	2.74	1.83	Low according to Berhanu (1980.
Total nitrogen (%)	0.14	0.09	Poor according to Tekalign et al. (1991).
Available phosphorous (ppm)	8.23	8.58	low According to Tekalign et al. (1991)

2.2. Treatments and Experimental Design

The experiment was laid down in randomized complete block design (RCBD) with factorial arrangement in three replications. There were a total of 20 treatments comprising five NPS rates (0, 25, 50, 75 and 100 kg ha^{-1}) and four nitrogen rates (0, 23, 46 and 69 kg ha^{-1}). Recently adapted linseed variety to the study areas (Kulumsa-1) was used as a test crop and planted at a seed rate of 25kg ha^{-1}.

2.3. Experimental Procedures and Field Managements

The experimental plot were plowed by oxen three times and fine seed beds were prepared before planting. The seeds were sowed at spacing of 20 cm between rows on the experimental plot. NPS fertilizer was applied in the row as per the treatment and mixed with soil just at the time of planting while nitrogen fertilizer was applied in split, 50% at sowing and the rest 50% at vegetative stage of the crop.

2.4. Soil Sampling and Analysis

Soil samples were taken at a depth of 0-30 cm in a zigzag pattern randomly from the experimental area before planting from both locations to determine the physico-chemical properties of the soil of the experimental locations. Composite samples were prepared separately for both locations. The composite soil sample was dried, ground and sieved. Total nitrogen was determined following the kjeldahl procedure as described by [11]; the soil pH was determined by using a digital pH meter [12] Organic carbon was determined following wet digestion method as described by [13]; and the available phosphorus was measured using Olson II methods [14].

3. Data Collected

3.1. Crop Phenology and Growth

Days to flowering, days to maturity, plant height (cm) and number of primary branches per plant.

3.2. Yield and Yield Components

Number of capsule per plant, above ground dry biomass (quintal ha-1) and grain yield (kg ha-1).

3.3. Quality Parameters

Oil content (%).

4. Statistical Data Analysis

Data subjected to analyses of variance using SAS 9.1 computer software and treatment means were separated using fisher least significant difference (LSD) test at 0.05 probability level. The economic analysis was done using SIMMYT manual 1988.

5. Results and Discussion

5.1. Crop Phenology and Growth

5.1.1. Days to Flowering and Days to Physiological Maturity

Days to flowering and days to physiological maturity were not significantly affected by the main and interaction effects of NPS and N fertilizer rates; rather is a significantly affected due to location difference. The crop took 77 days to flower and 158 days to mature at Chobi Tulu Chori location. However, it reached flowering and maturity at 87 and 183 days, respectively at Gitilo Dole location. (Table 2). The difference could be due to altitude and temperature differences. Prolonged crop phenology at higher altitude and lower temperature. The effects of increased temperature exhibit a larger impact on grain yield than on vegetative growth because of the increased minimum temperatures. These effects are evident in an increased rate of maturity which reduces the ability of the crop to efficiently fill the grain. Similarly, [15] stated that days to flower initiation and physiological maturity between locations differed significantly and both phenological events were delayed considerably at the higher elevations compared to the lowest elevation.

Table 2. Effect of NPS and nitrogen fertilizer rates on days to flowering and days to physiological maturity.

Treatment	Chobi Tulu Chori		Gitilo Dole	
	DF	DPM	DF	DPM
Nitrogen fertilizer				
0	77.26	159.03	87.27	183.60
23	77.13	158.23	87.13	182.93
46	77.00	158.10	86.93	182.87
69	76.87	157.43	86.20	182.73
LSD	NS	NS	NS	NS
NPS fertilizer				
0	77.33	158.00	87.67	182.75
25	77.17	157.83	86.25	182.50
50	77.00	158.17	86.92	183.58
75	77.00	158.50	86.93	183.25
100	76.83	158.50	86.67	183.08
LSD (0.05)	NS	NS	NS	NS
Mean	77.00	158.20	86.88	183.03
CV (%)	0.38	1.02	1.50.	0.67

DFI=Days to flowering; DPM=Days to physiological maturity; LSD=least significant difference; CV=coefficient of variation; NS=non-significant

5.1.2. Plant Height

Plant height was significantly ($P<0.05$) affected by the main effect of N fertilizer rates but not affected by the main effect of NPS fertilizer rates and their interaction effect. The highest plant height (86.01cm and 85.99 cm) were recorded from 69 kg ha^{-1} and 46 kg N ha^{-1} respectively (Table 3). When the amount of nitrogen increased from 0 kg to 69 kg the plant height also increased. The increase in plant height with increasing N fertilizer rate up to 69 kg N ha^{-1} could be explained by the stimulation effect for cell elongation directly after division [16]. In agreement with this result, [17] reported that plant height was increased as the rate of nitrogen fertilizer increased from 0 kg to 200 kg. Also [18] reported that increasing levels of N from 0 to 22.4 and 44.8 kg ha^{-1} significantly affect the plant height.

Table 3. *Linseed plant height and seeds per capsule as affected by NPS and N fertilizers at Chobi Tulu Chori and Gitilo Dole site during 2018 and 2019 main cropping season.*

Treatment	NSPC	PH (cm)
Nitrogen		
0	8.37	82.74b
23	8.49	84.66ab
46	8.32	85.99a
69	8.40	86.01a
LSD	NS	2.48
NPS		
0	8.37	84.25
25	8.50	84.97
50	8.21	85.20
75	8.48	84.43
100	8.40	85.38
LSD (0.05)	NS	NS
CV (%)	12.86	8.13

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;; NSPC=Number of seed per capsule; PH=plant height

5.1.3. Primary Branch per Plant

The analysis of variance over locations and year showed that primary branch was highly significantly (p<0.01) affected by main effect as well as their interaction effect of NPS and nitrogen fertilizer rates. The highest number of primary branches per plant (5.33.00 and 5.15) were recorded from application of 50 kg NPS ha^{-1} + 69 kg N ha^{-1} and 25 kg NPS ha^{-1} + 69 kg N ha^{-1} respectively. In line with this finding [19] stated that the number of primary branches per plant increased significantly as N rate increased up to 90 kg ha^{-1}. Also [20] stated that number of primary branches per plant was significantly increased with the application of 20 kg N and 20 kg P_2O_5 ha^{-1} as compared to control treatment**.**

Table 4. *Interaction effect of NPS and nitrogen fertilizer rates on primary branches at Chobi Tulu Chori and Gitilo Dole site during 2018 and 2019 main cropping season.*

Nitrogen fertilizer	NPS fertilizer				
	0	25	50	75	100
0	2.97h	3.66fg	3.54g	3.63fg	3.85e-g
23	4.25c-e	4.15d-f	4.23c-e	4.26c-e	4.23c-e
46	4.59cd	4.75bc	4.77a-c	4.67b-d	4.13d-f
69	4.78a-c	5.15ab	5.33a	4.58cd	4.28c-e
LSD (0.05)	0.56				
CV (%)	16.22				

Means with the same letter are not significantly different; LSD=Least Significant Difference; CV=Coefficient of Variation

5.2. Yield and Yield Components

The analysis of variance over locations and year showed that yield and yield components except seed per capsules were significantly ((P<0.01) affected by application of N and NPS fertilizer. The reaction of linseed to NPS fertilizer rates were low when examined with the reaction of linseed to N fertilizer rates.

5.2.1. Capsule per Plant and Seeds per Capsule

Capsule per plant was highly significantly (p<0.01) affected by the main effect of NPS and N fertilizer rates and their interaction effect. The highest capsule per plant (45.16 and 42.10) was obtained from the application of 25 kg NPS ha^{-1} + 69 kg N ha^{-1} and 25 kg NPS ha^{-1} + 46 kg N ha^{-1} respectively (Table 5). But number of seeds per capsule were not affected by main effect and interaction effect of NPS and N fertilizer rates (Table 3). The highest capsule per plant at higher N fertilizer may be due to the availability of nitrogen for plants is more when compared to the control treatment (0 kg NPS and 0 kg N). This indicates that Nitrogen is an important factor on distribution of photosynthetic assimilates between vegetative and reproductive organs. This result was in agreement with [21] the increased N application resulted in increasing number of capsules per plant and the highest number of capsules per plant obtained from the highest N application (92kg ha^{-1}).

Table 5. *Interaction effect of NPS and nitrogen fertilizer rates on Capsule per plant at Chobi Tulu Chori and Gitilo Dole site during 2018 and 2019 main cropping season.*

Nitrogen fertilizer	NPS fertilizer				
	0	25	50	75	100
0	29.25i	31.15g-i	39.16b-d	30.28hi	32.31g-i
23	32.20g-i	33.35f-h	37.20d-f	34.73e-g	29.35i
46	38.8c-e	42.10ab	41.66a-c	37.15e-f	32.70g-i
69	39.16b-d	45.16a	40.33b-d	34.78e-g	3311g-i
LSD (0.05)	3.91				
CV (%)	13.77				

Means with the same letter are not significantly different; LSD=least significant difference; CV=coefficient of variation

5.2.2. Above Ground dry Biomass (Quintal ha^{-1})

Above ground dry biomass was highly significantly (p<0.01) affected by the main effect of NPS and N fertilizer rates and their interaction effect. As the amount of nitrogen increased from 0 to 69 kg ha^{-1} the amount of above ground dry biomass also increased from 39.56 to 55.47 quintal ha^{-1}. But the increment of above ground biomass with the increment of NPS fertilizer rates was very low when compared to N fertilizer. The highest above ground dry biomass (59’33 quintal) was obtained from the application of 25 kg NPS ha^{-1} + 69 kg N ha^{-1}. This may be due to the availability of N to the plant increased and it causes increased plant height, number of capsules per plant and branches that contributed to the increment of aboveground biomass. This result was in agreement with [22] who stated that above ground biomass increased significantly when nitrogen fertilizer rates increased on French bean.

Table 6. *Interaction effect of NPS and nitrogen fertilizer rates on above ground dry biomass (quintal ha^{-1}) at Chobi Tulu Chori and Gitilo Dole site during 2018 and 2019 main cropping season.*

Nitrogen fertilizer	NPS fertilizer 0	25	50	75	100
0	39.56jk	36.60k	43.50g-j	44.09g-j	41.26i-k
23	42.46h-j	41.98h-j	46.96e-h	44.98f-i	44.27g-j
46	50.62b-e	53.82b-c	47.87d-g	45.75e-i	45.86e-i
69	55.47ab	59.33a	53.15b-d	52.51b-d	49.93c-f
LSD (0.05)	629				
CV (%)	14.10				

Means with the same letter are not significantly different; LSD=least significant difference; CV=coefficient of variation

5.2.3. Grain Yield (kg ha^{-1})

Grain yield was highly significantly (P≤0.01) affected by the main effects of NPS and nitrogen fertilizers and their interaction effect The highest grain yield (1400 kg ha^{-1} and 1382 kg ha^{-1}) were obtained from application of 25 kg NPS ha^{-1} + 69 kg N ha^{-1} and 25 kg NPS ha^{-1} + 46 kg N ha^{-1} respectively. The lowest grain yield (520 kg ha^{-1}) was recorded from the control treatment (0 kg NPS ha^{-1} + 0 kg N ha^{-1}) (Table 7). This indicates that 62.86% yield reduction was recorded as compared to the application of 25 kg NPS ha^{-1} + 69 kg N ha^{-1} fertilizer. Similar to others parameters of yield components; the reaction of grain yield to NPS fertilizer was low in amount than N fertilizer. This may be due to Mycorrhizae soil fungi that live in a symbiotic relationship with plants. According to [23] when linseed is not fertilized with P, yield is maintained and mycorrhizae infection is high but when linseed receives fertilizer P, mycorrhizae infection is reduced The increase of grain yield due to increasing nitrogen fertilizer rates might be due to the role of nitrogen in protoplasm and chlorophyll formation, enhancement of meristematic activity and cell division, consequently increases cell size which improves vegetative growth, plant height and branch number and capsule number. Moreover, nitrogen encourages plants to uptake other elements activating, thereby growth of plants, consequently enhancing growth measurements and all seed yield components. Also Nitrogen is an important factor on distribution of photosynthetic assimilates between vegetative and reproductive organs. This result in agreement with [24] who stated that the highest grain yield (2290.79 kg ha^{-1}) was obtained from the application of 90 kg N ha^{-1}.

5.3. Oil Content (%)

The oil content of linseed showed no significant response to NPS and Nitrogen fertilizers. Also the growing environments had no effect on oil content. However the result of laboratory tests indicated that the mean oil content was 38.56%. Which is found in the standard range of linseed oil 35-46% [3].

Table 7. *Interaction effect of NPS and nitrogen fertilizer rates on grain yield (kg ha^{-1}) at Chobi Tulu Chori and Gitilo Dole site during 2018 and 2019 main cropping season.*

Nitrogen fertilizer	NPS fertilizer 0	25	50	75	100
0	520j	645ij	874.17fgh	771.67hi	775.83ghi
23	922.50ef	930ef	995c-f	956.67def	1039.17cde
46	1085bcd	1382a	1126.67bc	908.33efg	1011.67cde
69	1097.50bc	1400a	1110.83bc	1180b	950def
LSD (0.05)	135.76				
CV (%)	17.14				

Means with the same letter are not significantly different; LSD=least significant difference; CV=coefficient of variation

5.4. Economic Evaluation

The economic assessments were made using partial budget analysis as described by CIMMYT [25]. The highest net benefit (35389 ETB) was obtained from the application of 25 kg NPS ha^{-1} + 46 kg N ha^{-1}. The lowest net benefit (14040 ETB) was obtained from control treatment (0 kg NPS ha^{-1} + 0 kg N ha^{-1}) Table 8. This indicate that net benefit increased till 25 kg NPS ha^{-1} + 46 kg N ha^{-1} fertilizer rates.

5.4.1. Dominance

The net benefit of most of the treatments were dominated except control plot (0 kg NPS ha^{-1} + 0 kg N ha^{-1}) and fertilizer rate of 25 kg NPS ha^{-1} + 0 kg N ha^{-1}, 0 kg NPS ha^{-1} + 23 kg N ha^{-1}, 50 kg NPS ha^{-1} + 23 kg N ha^{-1}, 0 kg NPS ha^{-1} + 46 kg N ha^{-1} and 25kg NPS ha^{-1} + 46 kg N ha^{-1} (Table 8). This indicated that the net benefit decreased as the total cost that varies increased beyond fertilizer rate of 25kg NPS ha^{-1} + 46 N kg ha^{-1}.

5.4.2. Marginal Rate of Return

As indicated in table 9; for each one birr invested, it was recover one birr plus an extra 6.50, 22.01, 1.91, 23.79 and 20.38 birr ha^{-1} as the fertilizer application changed from unfertilized plot until optimum level of 25 kg NPS ha^{-1} and 46 kg N ha^{-1}). According to [25] the minimum rate of return acceptable to farmers will be between 50% and 100%. If the technology is new to the farmers 100% minimum rate of return is a reasonable estimate. If the technology simply represents an adjustment in current farmer practice (such as a different fertilizer rate for farmers that are already using fertilizer), then 50% is a minimum acceptable rate of return.

Table 8. *Partial budget analysis of NPS and nitrogen fertilizers on linseed in 2018 and 2019 for both locations.*

Treatment (NPS + N)	Average Yield kg ha^{-1}	Adjusted yield (10%) kg ha^{-1}	Cost of NPS ha^{-1}	Cost of N ha^{-1}	Cost of labor for fertilizer Application ha^{-1}
0kg + 0kg	5.2	4.68	0	0	0
25kg + 0kg	6.45	5.805	375	0	75
0kg + 23kg	9.22	8.298	0	700	75
50kg + 0kg	8.74	7.866	750	0	75
25kg + 23kg	9.3	8.37	375	700	75

Treatment (NPS + N)	Average Yield kg ha^{-1}	Adjusted yield (10%) kg ha^{-1}	Cost of NPS ha^{-1}	Cost of N ha^{-1}	Cost of labor for fertilizer Application ha^{-1}
75kg + 0kg	7.72	6.948	1125	0	75
50kg + 23kg	9.95	8.955	750	700	2
0kg + 46kg	10.85	9.765	0	1400	150
100kg + 0kg	7.76	6.984	1500	0	150
25kg + 46kg	13.82	12.438	375	1400	150
75kg + 23kg	9.57	8.613	1125	700	150
0kg + 69kg	10.98	9.882	0	2100	225
100kg + 23kg	10.39	9.351	1500	700	150
50kg + 46kg	11.27	10.143	750	1400	225
25kg + 69kg	14	12.6	375	2100	225
75kg + 46kg	9.08	8.172	1125	1400	225
50kg + 69kg	11.11	9.999	750	2100	300
100kg + 46kg	10.12	9.108	1500	1400	300
75kg + 69kg	11.8	10.62	1125	2100	300
100kg + 69kg	9.5	8.55	1500	2100	300

Table 8. *Continued.*

Treatment (NPS + N)	Total variable cost	linseed Price (ETB kg^{-1})	Gross return (ETB kg^{-1})	Net benefit (ETB kg^{-1})
0kg + 0kg	0	30.00	14040	14040
25kg + 0kg	450	30.00	17415	16965
0kg + 23kg	775	30.00	24894	24119
50kg + 0kg	825	30.00	23598	22773 D
25kg + 23kg	1150	30.00	25110	23960 D
75kg + 0kg	1200	30.00	20844	19644 D
50kg + 23kg	1452	30.00	26865	25413
0kg + 46kg	1550	30.00	29295	27745
100kg + 0kg	1650	30.00	20952	19302 D
25kg + 46kg	1925	30.00	37314	35389
75kg + 23kg	1975	30.00	25839	23864 D
0kg + 69kg	2325	30.00	29646	27321 D
100kg + 23kg	2350	30.00	28053	25703 D
50kg + 46kg	2375	30.00	30429	28054 D
25kg + 69kg	2700	30.00	37800	35100 D
75kg + 46kg	2750	30.00	24516	21766 D
50kg + 69kg	3150	30.00	29997	26847 D
100kg + 46kg	3200	30.00	27324	24124 D
75kg + 69kg	3525	30.00	31860	28335 D
100kg + 69kg	3900	30.00	25650	21750 D

ETB=Ethiopian birr, D=Dominated

Table 9. *Marginal analyses of NPS and nitrogen fertilizers on linseed in 2018 and 2019 for both locations.*

Treatment (NPS +N)	TVC (ETB ha^{-1})	MC (ETB ha^{-1})	NB (ETB ha^{-1})	MB (ETB ha^{-1})	MRR (%)
0kg + 0kg	0.00		14040		
25kg + 0kg	450	450	16965	2925	650
0kg + 23kg	775	325	24119	7154	2201
50kg + 23kg	1452	677	25413	1294	191
0kg + 46kg	1550	98	27745	2332	2379
25kg + 46kg	1925	375	35389	7644	2038

TVC=total variable cost; MC=marginal cost, NB=net benefit MB=marginal benefit, MRR=marginal ret of return, ETB=Ethiopian birr,

6. Conclusion and Recommendation

Even though the production area of linseed is the second largest next to Noug, its productivity is still low as compared to its potential productivity.

The reason why the productivity is low in Ethiopia is due to lack of high yielder variety, poor agronomic practice special application of inorganic fertilizer is very low. Because the perspective of farmers is low about the importance of inorganic fertilizer for linseed production and therefore; farmers produce linseed without or little application of fertilizer.

The results revealed that the response of capsule per plant and grain yield to NPS fertilizer was smaller when compared to N fertilizer. When nitrogen fertilizer was increased from 0 kg ha^{-1} to 69 kg ha^{-1} the capsule per plant and yield was increased significantly.

The highest grin yield (1400 kg ha^{-1} and 1382 kg ha^{-1}) was obtained from the application of 25 kg NPS ha^{-1} + 69 kg N ha^{-1} and 25 kg NPS ha^{-1} + 46 N kg ha^{-1} respectively. The lowest grain yield (520 kg ha^{-1}) was recorded from the control treatment (0 kg NPS ha^{-1} + 0 kg N ha^{-1}). This indicates that 62.86% yield reduction was recorded as compared to the application of 25 kg NPS ha^{-1} + 69 kg N ha^{-1} fertilizer. When fertilizer rates of nitrogen increased from 0 kg ha^{-1} to 69 kg ha^{-1} the yield was increased significantly but, as fertilizer rates of NPS vary from 0 ha^{-1} kg to 100 kg ha^{-1} the observed difference was low on yield. The partial budget analysis indicated that highest net benefit (35389ETB) and acceptable marginal rate of return (2038%) were obtained from the application of 25 kg NPS ha^{-1} + 46 kg N ha^{-1}. Therefore application of 25 kg NPS + 46 kg N ha^{-1} fertilizer rates was recommended for linseed production in the study area and similar agroecology.

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