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Effect of Different Levels Application of NPS on Seed Yield and Oil Content of Linseed (*Linum usitasissimum* L.) in Bale Highlands, South Eastern Ethiopia

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Abstract: Linseed (*Linumusitatissimum* L.) has been a traditional crop and it is the most important oil seed crop in production in the higher altitudes of Ethiopia. The needs for applying fertilizers are becoming obvious, as soil fertility has declined from time to time. Excessive use of fertilizers also affects farmers' economy, as the crop is relatively low yielder. In order to study the effect NPS blended fertilizer levels the experiment was conducted at two locations in Bale, south eastern Ethiopia (Sinana on farm and Agarfa) to study effects of different levels on linseed performance for two consecutive years (2021-2022/23). The treatments were six rates of blended NPS fertilizer (0, 25, 50, and 75,100, and 125 NPS kg ha^{-1}) laid out in randomized complete block design (RCBD) with three replications. Linseed variety *'Hora soba'* was used as a test crop. The main effect of blended NPS levels did not reveal significant differences for the most of studied parameters at both studied locations. This might be due to medium to high soil nutrient status of the study sites. The instability of responses to application of fertilizer to this crop at Bale requires soil test based recommendation as this varied on a farm-to-farm basis.

Keywords: Blended Fertilizer, Linseed, Nutrient, Soil

1. Introduction

Oilseed crops can be grown in all parts of the country and are currently contributing a larger share to the agrarian economy of Ethiopia and are the second export products next to coffee and already more than 3 million small holders are involved in their production [12] Linseed is one of the most versatile and useful crops. Ethiopia is considered the secondary center of diversity, and now the 5th major producer of linseed in the world after Canada, China, United States and India [3].

Linseed yields seed which is rich source of both non-edible and edible oil. The industrial oil is an important ingredient in the manufacture of paints, varnishes and linoleum while edible linseed oil is used for human consumption and contains α-linolenic acid (ALA), a polyunsaturated fatty acid that is known to have nutritional and health benefits [9]. Aside from ALA, linseed is becoming increasingly popular as a nutritional and functional food in the Western world due to its high content of health promoting substances such as ω-3 fatty acid, soluble and insoluble fibre and lignans [10]. In most countries, linseed is only cultivated for its seed which is processed into oil and a high protein stock feed after oil extraction. Linseed is also suitable in crop rotation programs with cereals. Studies undertaken in this respect indicate that crops following linseed produce good yields since it prevents disease build up as it is resistant to cereal diseases.

Linseed is suited to a wide range of soil types but establishment can be difficult on heavy clay soils, as soils of a gravelly or dry sandy nature, which has to be avoided. A fine tilth and adequate moisture are required to ensure good establishment. Linseed requires cool temperature during its growing period for better yield. It prefers dry and sunny weather with well-distributed moderate rain over the growing season [7]. Linseed is grown in areas susceptible to frost because it has the ability to tolerate frost damage. On the basis of growth habit, two types (long stemmed and short stemmed) are recognized. Long stem linseed produces a high quality fiber but the oil content of the seed is relatively low. On the other hand, short-stemmed linseed bears larger seeds of high oil content and has branching tendency.

The Bale highlands are one of the potential areas for the production of highland oil crops in Ethiopia, and linseed is the main oil crop grown in the zone. Regarding its future prospect, however, it can be envisage that the need for large scale production of this potential oil crop is eminent, particularly with the advent of state farms and farmer's producer's cooperatives so as to satisfy the ever-increasing domestic demand for oil and moreover ample production for export. In general, with the present national trend of agricultural diversification, linseed commands increased research interest focused on the cultural aspect of different varieties. In Ethiopia, linseed is being produced under rainfed, low input and poor management. Concerning fertilizer utilization for linseed production, 89% of the farmers apply neither organic (manure, compost, etc.) nor inorganic fertilizer (DAP, Urea, etc.) [1]. only 7% of farmers apply 11 to 20 kg/ha DAP. Similarly, it was understood that Bale farmers apply little or no fertilizer for linseed production. Hence, it is important to incorporate improved management practices to the ever- increasing need of farmers to this crop for highest seed yield. Besides the crop is traditionally grown under marginal and sub-marginal production conditions of less fertile and poorly prepared soils, and no weeding practice at all [2]. Linseed seems to respond better in waterlogged soils and a rate of 23-25 kg N-P2O5 per ha seemed optimum and even application of higher N were justified under such heavy vertisol areas of Ethiopia [6]. This could be significant particularly in Ethiopia, where there is no micronutrient application in the form of chemical fertilizers or organic elements [5].

However in Sinana, research regarding use of new blended fertilizer type such as NPS and application method on growth, yield and oil content of the crop is non-existent and only little attention has been paid towards investigating the response of nitrogen and phosphorus. Therefore, the present study was initiated with the objectives of evaluating responses of improved new linseed variety to levels of application of NPS and assessing the economic feasibility.

2. Materials and Methods

Linseed variety '*Horasoba*' was used for the experiment. It is an improved variety released by Sinana Agricultural Research Center in 2019/20. The experiment was consisted of six rates of NPS including one unfertilized control: 0, 25, 50, and 75,100, and 125 NPS kg ha^{-1} and laid out in randomized complete block design (RCBD) with three replications. A field layout was prepared and the treatments were assigned randomly to each plot within a block. The replications, blocks and experimental units were separated by 1.5m 1m, and 1m respectively. Seeds were sown using row planting. Each plot consisted of six rows 20cm apart and 3m in length. The outer most one row on both sides of each plot served as a border. Thus the plot area was 3m x 0.8m ($2.4m^2$) used for data collection.

Soil samples were taken in a zigzag pattern from five sampling spots of the entire experimental field at 0-30cm depth using an auger before sowing. The composite soil samples were prepared by quartering and air-drying at room temperature, ground using a pestle and a mortar and allowed to pass through a 2mm sieve. Working samples were obtained from bulk sample and analyzed for total nitrogen, available P, cation exchange capacity (CEC), pH.

3. Results and Discussions

3.1. Soil Chemical Properties

The results of soil analysis (Table 1) showed that the soil reaction of the experimental sites were moderately neutral at Sinana and Agarfa, where the pH was 6.83 and 6.7, respectively This indicates that the soil reaction of the experimental sites is suitable for optimum growth and yield of most crops. According to [3], linseed will not perform well on soils with pH less than 5.0 or above 7.0, which show that the crop is sensitive to both soil acidity and alkalinity. The CEC value of the soil was high at Agarfa and very high at Sinana; this indicates that the soil has relatively high capacity to hold nutrient cation and supply to the crop. The analysis results of soil NPS showed that medium to high for each nutrient analyzed.

Total nitrogen was analyzed and determined by the Micro-Kjeldahl digestion method with sulphuric acid [8]. Sulphur was analyzed by turbidimetric method [4]. Available phosphorus was determined by the Olsen method [11].

Table 1. *Chemical properties of the experimental soil before planting.*

Parameters	Sinana	Agarfa
Chemical Properties		
pH in water (1:2.5)	6.83	6.7
CEC (cmol. (+) kg $soil^{-1}$)	48.56	37.38
Total N (%)	0.18	0.17
Av. P (ppm), Olsen	10.12	11.7
AV.S (mg kg^{-1})	22.17	21.17

3.2. Effect of NPS Levels on Yield and Yield Components of Linseed at Sinana and Agarfa

The analysis of variance result showed that applications of different levels of NPS did not significantly affects most of the studied parameters of linseed both at Sinana on farm and Agarfa probably due to relatively medium to high accumulations of studied nutrients. Under nutrient sufficient and conducive environmental conditions plants in the range of studied factor levels did not interact or compete. Different reports by different researchers revealed that seed yield of linseed varied with site and year without showing a constant trend and some studies points to a limited response to NPS application when soil nutrient levels are high. In such a situation, the use of fertilizer on linseed would normally be unnecessary. Thus, a combination of soil test and cropping history should be followed in the linseed fertility program.

***Table 2.** Effect of different levels application of NPS on seed yield, oil content and yield components of Linseed (Linum usitasissimum L.) at Selka, 2022/23.*

Treatments	DFL	DM	PHT	NTP	NPB	NCP	NSP	BYD	SYD	TSW	POC	HI
NPS kg ha^{-1}												
0	75.3	154.3ab	97ab	1.8	5.1	38.25d	8.7	6482^{ab}	1156.6	6.0ab	40.7	18.1
25	75	154ab	96.8ab	2.1	4.6	45.85d	8.3	5544^{ab}	1276.0	6.0ab	39.3	21.4
50	75	155a	94.7b	2	4.6	60.9c	8.3	6737a	1490.4	6.4a	40.2	22.1
75	75	152.7b	100.2a	1.7	4.2	63.8c	6.7	5826^{ab}	1206.8	5.8b	39	20.3
100	75	155a	97.5ab	2.4	4.6	37.8a	8	3523b	1308.0	6.3ab	38.4	20.8
125	73.3	152.3b	100.2a	1.6	4.3	26.3a	8.3	5729^{ab}	1068.7	5.8b	39.1	18.2
$LSD_{0.05}$	ns	2	4	ns	ns	11.5	ns	2767	ns	0.4	ns	ns
CV (%)	2.8	3.8	2.3	25.8	12.5	16.3	15.2	25.2	22.2	4	5.2	11.3

Keys: DFL= Days to flowering, DM= Days to maturity, PHT=Plant height, NTP=Number of tillers per plant, NPB= Number of primary branches per plant, NCP=Number of capsules per plant, NCP= Number of capsules per plant, NSP =Number of seeds per capsule, BYD=Biological yield (kgha^{-1}), SYD (kgha^{-1})=Seed yield, TSW=Thousand seed weight, POC=Percent oil content HI=Harvest index, LSD=Least significant difference (5%), CV=Coefficient of variation

***Table 3.** Effect of different levels application of NPS on seed yield, oil content and yield components of Linseed (Linum usitasissimum L.) at Agarfa, 2022/23.*

Treatments	DM	PHT	NTP	NPB	NCP	NSP	BYD	SYD	TSW	POC	HI
NPS kg ha^{-1}											
0	176	96^{ab}	2.9^{ab}	2	49.4	8.7	6851.9b	1283.1	6.6	39.9	18.7
25	176	97.3^{ab}	2.8^{ab}	2	49.2	8.3	7222.2ab	1386.8	6.6	40.7	19.2
50	173.3	103a	3.6^{a}	2	49.7	8.7	9074.1a	1442.6	6.7	40.3	16.1
75	177.3	96.3^{ab}	2.9^{ab}	2	57.0	8.3	6851.9b	1422.1	6.7	39	21.1
100	174.7	95.8^{b}	3^{ab}	2.3	67.5	8.7	7777.8ab	1330.1	6.7	39.8	17.0
125	173.3	90.2^{b}	2.7^{b}	2.3	59.2	7.7	6666.7b	1322.9	6.7	40.2	20.0
$LSD_{0.05}$	ns	7.3	0.76	ns	ns	ns	1780	ns	ns	ns	ns
CV (%)	2	4.1	14.5	25.2	30.2	11.0	13.2	12.3	1.5	6.8	13.7

Keys: DFL= Days to flowering, DM= Days to maturity, PHT=Plant height, NTP=Number of tillers per plant, NPB= Number of primary branches per plant, NCP=Number of capsules per plant, NCP= Number of capsules per plant, NSP =Number of seeds per capsule, BYD=Biological yield, SYD=Seed yield, TSW=Thousand seed weight, HI=Harvest index, LSD=Least significant difference (5%), CV=Coefficient of variation.

4. Conclusion and Recommendations

Studies were conducted regarding blended NPS fertilizers levels at Sinana and Agarfa to determine growth and yield of linseed. The results of the soil tests revealed that most of the chemical properties of the experimental sites were indicative of medium to high fertility status. The results of the field experiment revealed almost all parameters were not significantly affected by the main effect of blended fertilizer levels probably due to relatively high accumulation of nutrient status in the studied sites. Therefore, the right amount of blended fertilizer should base on analysis of limiting nutrients and studies should encompass different localities under different season than under similar locations.

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Conflicts of Interest

I declare no conflicts of interest.

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