Effects of fertilizer rate and spacing on growth and seed yield of sunflower (*Helianthus annuus L.*) in northwestern Amhara, Ethiopia

ABSTRACT

Sunflower is one of the most important oil crops in Ethiopia. However, the productivity of the crop is very low due to lack of proper agronomic recommendations. Therefore, a field experiment was conducted to evaluate the effects fertilizer rates and spacing on growth and seed yield of sunflower in Achefer and Jabitehinan districts from 2017 to 2018 G.C. The treatments consisted of a factorial combination of four plant population densities (60/20, 60/25, 75/25 and 75/30 inter/intra row spacing) and four nutrient rates (0/0, 23/23, 46/46 and 69/69 Kg ha^{-1} of N/P_2O_5) which were laid out in randomized complete block design with three replications. Plant height, head diameter, seed weight per head, thousand seed weight and seed yield were recorded and analyzed. The results showed that the main effect of nutrient rates was significantly affected the growth and seed yield of sunflower. The longest plant height (281.3 cm), and the highest thousand seed weight (62.99 g) and seed weight per head (464.89 g) were recorded from 69/69 Kg ha^{-1} N and P_2O_5 nutrient applications. The highest grain yield (2658.82 Kg ha^{-1}) was recorded at 46/46 Kg ha^{-1} N and P_2O_5 nutrient levels while the lowest yield (2105.67 Kg ha^{-1}) was recorded from the unfertilized control. The growth and yield of sunflower not significantly affected by the main effect of spacing and the interactions with inorganic fertilizer levels. The highest net benefit of ETB 24,162.99 ha^{-1} with an acceptable level of marginal rate of return (124%) obtained from the combined application of 23/23 Kg ha^{-1} N/P_2O_5 nutrient rate and 75x30 cm inter/intra row spacing to be recommend for north Achefer and Jabitehinan soil and climatic condition.

Key words:

INTRODUCTION

Sunflower (L.) is one of the most important oil seed crops in the world for its wider range of adaptability and highest seed oil contents (40-50%). It ranks fourth next to soybean, groundnut and rapeseed in the total production of oil seeds in the world (FAO 2014). Sunflower was cultivated in an area of 25.3 million hectares with annual production and productivity of 53.94 million tones and 1410 Kg ha^{-1}, respectively, in the year 2021 (FAO 2021). In Ethiopia, sunflower is one of the eight most important oil crops with annual production and productivity of 9576.9 ton and 1202 Kg ha^{-1}, respectively (CSA 2018). Even though the crop has a high potential to become a competent oil crop in the country, much progress didn`t achieved in improving the agronomic practices (Alemaw and Gurmu 2023). Inappropriate agronomic practices especially optimum nutrition and plant population greatly affect the productivity of sunflower (Crnobarac 2004).

Nutrients play an important role in the growth and development of sunflower. Among these, nitrogen and phosphorous are the most important nutrients in increasing the yield and quality of sunflower. According to Ali (2014), Ozer (2004), Osman and Awed (2010), the recommended quantity of nutrients of N and P are an effective approach to improve the yield and quality of sunflower. Hedge and Babu (2009) stated that sunflower is an important fast growing and high-yielding oil seed crop, which removes a considerable amount of nutrients to the extent of 63.3 Kg N, 19.1 Kg P_2O_5 and 126.0 Kg K_2O to produce one-ton seed yield. Similarly, Shaktawat and Bansal (1999) suggested that since sunflower is an exhaustive crop, adequate nutrition plays an important role in boosting the production. In other similar studies, Sirbu and Ailincai (1992) found that application of 80 Kg ha^{-1} N, 80 Kg ha^{-1} P_2O_5 and 80 Kg ha^{-1} K_2O produced the highest sunflower seed yield of 3.5 t ha^{-1} in northern India. Moreover, Kharchenko and Hartchenko (1992) noticed that an increased sunflower seed yield was achieved by 0.2 t ha^{-1} at application rate of 90-90-90 Kg ha^{-1} of NPK fertilizer. Jagtap and Sabale (1994) also reported that 80 Kg ha^{-1} of N as an optimum dose of nitrogen for better sunflower yields. However, excessive application of fertilizers affects the farmer's economy (Zubillaga 2002).

Proper plant-to-plant spacing provides sufficient interception of light and satisfactory absorption of nutrients and water from the soil. According to Saleem and Wahid 2008) and Yasin . (2011), radiation interception, evapotranspiration and water use efficiency of sunflower greatly affected by plant population. They also confirmed that sunflower population for optimum yield could be at the rates of 30,000 to 50, 000 plants per hectare. North Dakota State University (2007) also reported that sunflower plants compensate for differences in plant population by adjusting seed and head size. FAO (2010) revealed that a plant density of 50,000 to 80,000 plants per hectare is required to form the optimum leaf area for plant photosynthesis, 1000 seed weight of 40-80 g and 1200-1500 average numbers of seed in a sunflower. Similarly, in Ethiopia plant population of 44,000 to 53,000 plants per hectare with respective inter and intra-spacing of 75 and 25 cm was found to be optimum for late maturing varieties, while 53,000 to 88,000 plants per hectare was optimum for early varieties (Hiruy Belay 1990). However, Tenaw Workayehu (1990) reported that there were no significant differences in higher and lower densities of plantings due to compensation effects of large heads and more seed number per head in lower densities. Robert (2002) also indicated that sunflower is not sensitive to seeding rate, because head size and seed number per plant will increase in a wider spacing.

However sunflower grower of Ethiopia heavily depend on planting of high seed rate without any recommended nitrogen and phosphrous nutrient. As the result the yield is low and considerably variey from area to area in north west Amhara. In general, insufficient application of N and P nutrient limit crop yield while excessive N and P applications result in tall plants with large leaves more prone to lodging and disease. Hence, fertilization and seeding rate need to be rationally optimized in order to avoid a negative ecological impact and undesirable effects on the sustainability of agricultural production systems. Therefore, this study was conducted with the objectives of determining optimum plant population density and fertilizer rate for agronomic and economic optimum sunflower production.

MATERIALS AND METHODS

Description of the study area

A field experiment was conducted in north Achefer and Jabitehinan districts of west Gojjam-zone in Amhara Region at two sites per district (Figure 1). Both districts are the major producer of sunflower in the region. North Achefer district is located at 11°24' 12'' to 11°9’ 12’’N latitude and 36°51’12’’ to 37°24’ 12’’E longitudes with an altitude ranging from 1500 to 1800 meters above sea level. The area receives an average annual rainfall ranging from 1000 to 1500 mm. The mean annual minimum and maximum temperatures were 12.1°C and 27°C, respectively. The major crops grown in the area are finger millet, teff and maize. The second location, Jabitehinan is located at 10° 42' 33" to 10° 42' 06 "N latitude and 35° 07' 03" to 35°25' 02 "E longitude. The altitude of the district ranges from 1500-2300 meters above sea level. According to the woreda office of Agriculture, the topography is 65% plain, 15% mountainous, 15% undulating and 10% valley. The temperature of the woreda ranges between 14°C to 32°C, with an average annual temperature of 22°C. The dominant crops in the study area are maize, pepper, millet, and teff (MoA 2010).

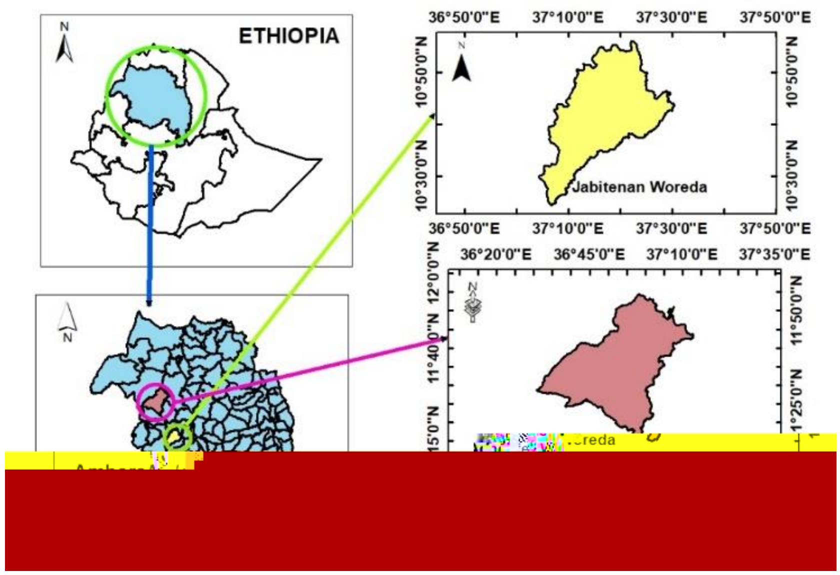

Figure 1: Location map of the study district

Treatments and Design

The experiment consisted of complete factorial combinations of four row spacing (60/20, 60/25, 75/25 and 75/30 cm inter/intra-row spacing) and four fertilizer rates (0/0, 23/23, 46/46 and 69/69 N/P_2O_5 Kg ha^{-1}) laid out in randomized complete block design (RCBD) with three replications. The whole DAP and 1/3 of N were applied at planting while the remaining 2/3 of N was top dressed when the crop reached 30 cm height. The gross plot size of each plot was 3.75 by 4.0 meters with total of 15 m^2. Three seeds per hole were planted and later was thinned to one plant after two weeks of emergence. Alley spacing between plots and replications were 1 and 2 m, respectively. The preceding crop was maize in both districts. Seedbed was prepared by cultivating the soil 3 times with oxen plow to a depth of 20 cm followed by planking. The planting dates were ranging from 12 to 19 June whereas harvesting dates ranges from 16 to 24 October in both locations. The first weeding was 20-25 days after planting whereas the second weeding was 35-45 days after planting. Diseases and insect pests were not a problem during the experimental periods. Regular monitoring was conducted to avoid bird damage.

Agronomic Data Collection and Analysis

Ten plants randomly selected and tagged for data collection. Data on plant height, head diameter, seed weight per head, thousand seed weight and seed yield were collected from each plot and statistically analyzed using SAS system (SAS 2002). Least Significant Difference (LSD) test was applied to compare means following the methods suggested by Gomez and Gomez (1984). Initially, the performance of the treatment evaluated separately for each location and then was combined in over locations.

Partial Budget Analysis

Partial budget analysis including marginal rate of return was analyzed using the technique described by CIMMYT (1988). The method used to assess the costs and benefits of the treatments. It considers the analysis of gross benefit (GB), total variable cost (TVC), net benefits (NB) and finally the analysis of the marginal rate of return. The actual grain and straw yields were adjusted down by 10% to reflect the difference between the experimental and the farmers' yield that would expect to get from the same treatment.

Soil Sample Collection and Analysis

The pre-planting soil samples of each experimental site were randomly collected from three spots diagonally from a depth of 0-20 cm. The samples were composited, bagged, air-dried, labeled and about one Kg of the samples was sent to Soil Laboratory of Adet Agricultural Research Center for determination of selected physico-chemical properties. The soil texture was determined using the Bouyoucos hydrometer method and pH at 1:2.5 soils to water ratio was determined using a glass electrode attached to pH digital meter. Total N was determined by the Kjeldahl method (Jackson 2005). Available P was determined by the Bray1 method, while organic matter was determined by Walkley and Black methods.

RESULTS AND DISCUSSIONS

The pre-sowing soil analysis results showed that the soil textural class in both sites are clay with a particle size distribution of 54%, silt 28% and sand 18% at north Achefer and clay 51%, silt 30% and sand 19% at Jabitehinan district (Table 1). This indicated that there was no big difference between the soil of Jabitehinan and Achefer in soil texture. According to Tekalign (1991) and Defoer (2000), the locations are moderately acidic in status and low in organic carbon, nitrogen and phosphorus contents (Table 1).

Table 1: Soil physico-chemical properties of testing sites

Soil properties	North Achefer	Jabitehinan	Status	Reference
Sand (%)	18	19		
Silt (%)	28	30		
Clay (%)	54	51		
PH	5.08	5.1	moderately acidic	Tekalign Tadese (1991)
Organic carbon (%)	0.78	0.80	low	Defoer (2000).
Total nitrogen (%)	0.12	0.11	low	Tekalign Tadese (1991)
Available P (mg/Kg)	7.2	7.8	moderate	Tekalign Tadese (1991)

The analysis of variance showed that the grain yield of sunflower was significantly ( ) affected by the main effects of fertilizers in both locations (Table 2). Nevertheless, the growth and yield of sunflower were not significantly ( ) influenced by location (L) and the interaction of spacing with fertilizer and the three-way interactions of spacing* fertilizer*location. Plant height, head diameter, seed weight per head and seed yield of sunflower were significantly ( ) affected mainly by the main effects of fertilizer at north Achefer (Table 2). Spacing significantly ( ) affected the plant height and head diameter of sunflower

Table 2: Mean squire of the growth and seed yield of sunflower in response to inorganic fertilizer rates and spacing in combined over locations

Source of variation	Degree of freedom	Plant height (cm)	Head diameter (cm)	Seed weight per head (g)	Thousand seed weight (g)	Grain Yield (Kg ha^{-1})
Replication	2	11600.9	44.541	0.008	193.7	256340
year	1	468.638	13.463*	44.541	54.27*	6474977
Location (L)	1	3592.7	1.072	13.463	297	3631581
Fertilizer (F)	3	1901.04*	113.742*	1.072*	125*	7155901*
Spacing (S)	3	359.6*	4.768*	113.742	41.44	193659
F*S	9	228.291	2.496	4.768	30.96	566863
F*S*L	15	385.818	44.541	2.496	23.35	256340

The highest plant height (283.75 cm), head diameter (19.54 cm), seed weight per head (409.45g) and seed yield (2657.64 Kg ha^{-1}) were recorded at 69/69 N/P_2O_5 fertilizer rate. However, the grain yield (2539.75 Kg ha^{-1}) and other growth parameters obtained at 46/46 Kg ha^{-1} of N/P_2O_5 were statistically at par with 69/69 N/P_2O_5 fertilizer rates. The shortest plant height (259.45 cm), head diameter (18.62 cm), seed weight per head (337.25 g) and grain yield (1871.91 Kg ha^{-1}) were recorded on unfertilized control. The improvement in the yield of sunflower at 69/69 N/P_2O_5 was nutrient at this rate adequately address the demand for sunflower in north Achefer. N and p are both major nutrients that enhance the metabolic processes on protein and ATP synthesis, which leads to increases in vegetative, reproductive growth and yield of the crop (Anas 2020). The result is in line with Khakwani (2014) who showed the yield of sunflower was highly increased by the application of a high level of fertilizer (150 and 120 Kg ha^{-1} of NP). Consequently, Yasin (2013) confirmed that treatments receiving a high level of fertilizer ratio produced larger head size, higher seed yield, 1000 seed weight, and higher total number of seeds $head^{-1}$ of sunflower.

The main effects of spacing and the interaction effects of fertilizer with spacing did not significantly ( ) affect the seed yield and other growth parameters of sunflower in north Achefer. The variation in spacing significantly ( ) affects only the head diameter and seed $head^{-1}$ of sunflower (Table 3). The largest head diameter (19.7 cm) and seed weight $head^{-1}$ (391.34 g) were recorded at a wider spacing (75x30) of sunflower. The narrowest head diameter (18.49 cm) and seed weight per head (337.47 g) were recorded at a closer spacing (60/20 cm) of sunflower (Table 3). The seed yields of sunflower were not significantly ( ) affected by different levels of plant spacing. The absence of a statistically significant ( ) difference on the seed yield of sunflower might show that larger spacing compensated by increasing its head diameter and seed per head. This is in line with, Mojiri and Arzani (2003) who showed a lack of difference in seed yield of sunflower at different plant spacing was due to the compensation effect of increasing the size of head diameter, and seed number per head. Robert (2002) also indicated that sunflower is not sensitive to seeding rate, because head size and seed number per plant will increase heavily in a broader spacing. In another similar study, Curotti and Rosania (2011) found that increasing the spacing between plants produced shorter plants, larger stalk diameters, higher seed weights and increased yields in sunflowers (Table 3).

Table 3: Growth and yield of sunflower in response to fertilizer and spacing in North Achefer

Treatment	PH (cm)	HD (cm)	SWPH (g)	TSW (g)	Seed yield (Kg ha^{-1})
Fertilizer (N/P_2O_5 Kg ha^{-1})					
0/0	259.45^{c}	18.62^{b}	337.25^{b}	58.18	1871^{c}
23/23	271.58^{b}	18.81^{ab}	360.06^{b}	58.36	2338^{b}
46/46	283.09^{a}	19.07^{ab}	367.39^{b}	60.34	2539^{ab}
69/69	283.75^{a}	19.54^{a}	409.45^{a}	61.30	2657^{a}
LSD	7.7	0.87	33.5	2.7	246.06
Sig	*	**	**	ns	*
Spacing (cm)					
60/20	276.56	18.49^{b}	337.47^{c}	58.19	2338
60/25	272.52	18.53^{b}	357.98^{bc}	60.32	2291
75/25	274.42	19.32^{a}	387.36^{ab}	59.10	2435

75/30	273.36	19.70^{a}	391.34^{a}	60.56	2310
LSD	7.7	0.87	33.5	2.7	246.06
Sig	ns	**	**	ns	ns
CV (%)	4.77	4.88	10.58	5.53	17.25

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The main effect of fertilizer rate significantly ( ) affected plant height, head diameter, seed weight head^{-1}, thousand seed weight and seed yield of sunflower in Jabitehinan district (Table 4). The highest plant height (279.9 cm), head diameter (20 cm) and seeds weight head^{-1} (520.33 g) and thousand seed weight (64.68 g) were recorded at 69/69 N/P_2O_5 Kg ha^{-1} fertilizer rates while the lowest was from unfertilized control (Table 4). The highest seed yield (2777.89 Kg ha^{-1}) was recorded at 46/46 Kg ha^{-1} of N/P_2O_5 fertilizer rate whereas the lowest seed yield (2339.5 Kg ha^{-1}) was recorded from unfertilized control. The results showed that increasing the level of nutrients was substantially enhanced the yield and yield traits of sunflower. Vigorous vegetative growths were observed at the highest N and P treated plots, since nutrients are necessary to correct the initial soil deficiencies. This was due to adequate supply of N and P is associated with high photosynthetic activity, vigorous growth and dark green color of leaves. The result is in line with Mojiri and Arzani (2003) who reported an increase in total dry matter and yield of sunflower was observed at maximum N and P fertilizer levels.

The variation in plant population densities showed a highly significant ( ) effect on seed weight head^{-1} and significant ($P<0.05$) effect on head diameter and seed yield of sunflower at Jabitehinan (Table 4). However, variation plant population densities did not significantly ( ) affect plant height and thousand seed weight of sunflower. The highest grain yield (2736.63 Kg ha^{-1}) was recorded at 60/25 inter/intra-row spacing. Head diameter (20.1 cm) and seed weight per head (540.24 g) were the highest at 75/30 inter/intra-row spacing. This is in conformity with Ali 2014) who had revealed maximum head diameter (18.76 cm) at wider plant spacing (70x25 cm). Results reported by Ali 2014) indicated that compensations of sunflower yield through increasing head diameter and seeds per head are very common.

Table 4: Yield and yield component of sunflower in response to fertilizer and spacing at Jabitenan

Treatment	PH (cm)	HD (cm)	SWPH (g)	TSW (g)	Seed yield (Kg ha^{-1})
Fertilizer					
0/0	255.25^{c}	18.67^{b}	416.14^{c}	61.38^{b}	2339^{c}
23/23	268.42^{b}	18.90^{ab}	472.71^{b}	62.92^{ab}	2450^{bc}
46/46	279.15^{ab}	19.04^{ab}	510.04^{a}	63.6^{ab}	2777^{a}
69/69	279.9^{a}	20.00^{a}	520.33^{ab}	64.68^{a}	2585^{b}
LSD	9.2	1.12	40.46	2.90	156.3
sig	**	*	**	*	**
Spacing					
60/20	272.85	18.22^{b}	421.85^{c}	62.92	2498^{b}

60/25	270.52	18.85^{b}	470.42^{b}	62.32	2736^{a}
75/25	270.91	19.28^{ab}	486.7^{ab}	63.21	2434^{b}
75/30	264.77	20.1^{a}	540.24^{a}	64.13	2484^{b}
Sig	ns	*	**	ns	*
CV (%)	8.5	14.56	20.93	11.42	15.24

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The overall combined experimental results indicated that the main effect of fertilizer significantly affected all growth parameters and seed yield of sunflower (Table 5). The highest plant height (281.83 cm), head diameter (19.77 cm), seed weight per head (464.89 g) and thousand seed weight (62.99 g) were recorded at 69/69 Kg ha^{-1} N/P_2O_5 fertilizer rates whereas the highest seed yield (2658.82 Kg ha^{-1}) obtained at 46/46 Kg ha^{-1} N/P_2O_5 fertilizer rates (Table 5). However, the seed yield at 46/46 Kg ha^{-1} N/P_2O_5 fertilizer rates is statistically at par with 69/69 Kg ha^{-1} N/P_2O_5 fertilizer levels. The lowest seed yield (2105 Kg ha^{-1}) was recorded from unfertilized control.

Table 5: Sunflower yield and yield components in response to fertilizer and spacing combined over locations

TRT	PH (cm)	HD (cm)	SWPH (g)	TSW (g)	Seed yield (Kg ha^{-1})
Fertilizer					
0/0	257.34^{c}	18.66^{b}	376.7^{c}	59.77^{b}	2105^{c}
23/23	270.00^{b}	18.76^{b}	416.38^{ab}	60.64^{b}	2378^{b}
46/46	281.3^{a}	19.05^{a}	438.72^{a}	61.97^{ab}	2658^{a}
69/69	281.83^{a}	19.77^{a}	464.89^{a}	62.99^{a}	2621^{a}
sig	**	*	**	*	**
Spacing					
60/20	274..7	18.37^{c}	379.60^{c}	60.55	2418
60/25	271.52	18.67^{bc}	414.2^{b}	61.32	2514
75/25	272.69	19.33^{ab}	437.3^{a}	61.16	2434
75/30	269.06	19.90^{a}	465.79^{a}	62.34	2397
sig	ns	**	**	ns	ns
CV (%)	3.47	4.29	6.15	4.57	11.46

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The superiority of yield and yield-contributing traits of sunflower at the maximum level of nutrient rate showed that nutrient deficiency properly corrected at 46/46 Kg ha^{-1} N/P_2O_5 nutrient rates in Jabitehinan and north Achefer soil and climatic conditions. The result is in line with Nasim (2012) who indicated that increasing nutrient rate of nitrogen and phosphorous ultimately increases the seed yield of sunflower. Nasim (2011) also reported that dry matter, seed yield and its attributes improved due to increases in nitrogen nutrient levels. Furthermore, Osman and Awed (2010) reported that increasing seed yield was observed as nutrient levels increases.

Zubillaga (2002) and Giorgio (2007) further confirmed that N and P nutrients are among the major nutrients that enhance the metabolic processes and lead to increases in vegetative, reproductive growth and yield of the crop.

Partial Budget Analysis

To identify treatment with the optimum rate of return to growers' investment, a partial budget analysis was performed following the standard procedures (CIMMIT 1988). Partial budget analysis indicates the worth fullness of the investment. Seed, nutrient and labor costs were the cost that varied across treatments. Total variable cost was the highest (ETB 5,340 ha^{-1}) at 69/69 Kg ha^{-1} N/P_2O_5 nutrient rate and 75x30 cm inters/intra row spacing while the lowest was on unfertilized control. The highest gross benefit of ETB 26,303 ha^{-1} was recorded at 23/23 Kg ha^{-1} N/P_2O_5 nutrient rate and 75x30 cm inters/intra row spacing while the lowest was again on unfertilized control. When compared with other treatments, the highest net benefit (ETB 24, 162.99 ha^{-1}) with an acceptable level of MRR (123.49%) was recorded at 23/23 Kg ha^{-1} N/P_2O_5 nutrient rates and 75/30 cm inter/intra row spacing (Table 6).

Table 6: Cost-benefit analysis of sunflower in response to spacing and nutrient rates

Treatments		Adjusted grain yield (Kg ha^{-1})	Labor cost (ETB ha^{-1})	Fertilizer cost (ETB ha^{-1})	TVC (ETB ha^{-1})	Gross Benefit (ETB ha^{-1})	Net Benefit (ETB ha^{-1})	MRR (%)
N/P_2O_5	Inter/intra row							
0/0	75/30	2366.6	960.01	0	960.01	23665.8	22	-
	75/25	2317.8	1155	0	1155	23177.5	22	
	60/25	2133.7	1439.3	0	1439.3	21336.5	19	
	60/20	1883.8	1800	0	1800	18837.6	17	
23/23	75/30	2630.3	960.01	1180	2140.0	26303	24	123.4
	75/25	2475.7	1155	1180	2335	24757.2	22	
	60/25	2130.8	1439.3	1180	2619.3	21308.2	18	
	60/20	1943.6	1800	1180	2980	19436.1	16	
46/46	75/30	2332.9	960.01	2360	3320.0	23328.5	20	
	75/25	2335.2	1155	2360	3515	23352.0	19	
	60/25	2260.3	1439.3	2360	3799.3	22602.5	18	
	60/20	1839.2	1800	2360	4160	18392.1	14	
69/69	75/30	2237.3	960.01	3540	4500.0	22373.4	17	
	75/25	2443.1	1155	3540	4695	24430.7	19	
	60/25	2038.6	1439.3	3540	4979.3	20385.5	15	
	60/20	1912.1	1800	3540	5340	19120.8	13	

Note: * J J ct J
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CONCLUSIONS AND RECOMMENDATIONS

Yield and yield traits of sunflower exhibited significant responses to the increasing level of nitrogen and phosphorus source of fertilizer in both districts. Grain yields were high at higher fertilizer rates and become low at lower fertilizer levels. This implies that the soils of the study districts were initially scarce to the most yield-limiting nutrients and only adequate application of N and P source fertilizer will sustain sunflower production in the study area. However, spacing did not significantly affect sunflower seed yield due to the compensating effect of the increased in head diameter and number of seeds per head when the spacing was wider. Nevertheless, achieving maximum seed yield at a higher rate of nutrient may not be economical as an investment without considering the economic analysis. Partial budget analysis was performed and 23/23 Kg ha^{-1} of N/P_2O_5 nutrient rates with 75/30 inter and intra row spacing offer maximum net benefit (ETB 24162.99 ha^{-1}) with an acceptable level of MRR (123.49% %) and recommended for sunflower production in north Achefer and Jabitehinan districts.

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