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Nitrogen Management of Diverse Sunflower (*Helianthus annus* L.) Hybrids Production under Agro-Climatic Conditions of Sargodha, Pakistan

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Abstract

A field study was carried out with the objective to determine the effect of various levels of nitrogen on growth, development, yield and yield components of different sunflower (*Helianthus annuus* L.) hybrids *i.e.* Hysun-33 and S-78 were evaluated under agro-climatic conditions of Sargodha, Pakistan during spring 2013. The experiment was laid out in a randomized complete block design with split plot arrangement having three replications, keeping cultivars in the main plots and N levels in the subplots. The net plot size was 4.2 m × 6 m. The growth parameters such are leaf area, leaf area duration and yield parameters were observed are Days to a thesis, Days to maturity, head diameter (cm), No. of achene's per head, Achene yield (kg·ha^{-1}) and total dry matter (kg). The results showed that increasing the nitrogen rate also increased the No. of achene's per head, Achene yield (kg·ha^{-1}) and total dry matter (kg) in S-78 hybrid where the nitrogen application rate was 180 kg·ha^{-1} as compared to Hysun-33 cultivar.

Keywords

Sunflower, Nitrogen, Growth and Yield

1. Introduction

Sunflower (*Helianthus annuus* L.) is an important oilseed crop which ranks 3rd after soybean and peanut along with other oil seed crop like (canola, and cotton)

which contributes considerably to edible oil in the world (Thavaprakash *et al.* [1]). In Pakistan, sunflower occupies an important place in oil seed crops because of short duration, having ability to adapt wide range of climate and soil conditions (Thavaprakash *et al.* [2]). Although, this crop has ideal place in the present cropping system but due to some constraints the average yield is much lower than world's average. The low productivity is mainly due to poor fertility of soils, lack of proper production technology, unavailability of inputs, and marketing problems (Anwar-ul-Haq *et al.* [3]; Arshad *et al.* [4]).

There are various factors responsible for obtaining the higher yield of sunflower such as nitrogen fertilizer is consider an essential nutrient play an imperative role in maximization of crop yields (Massignam *et al.* [5]) and improves the yield as well as quality of all crops (Dreccer *et al.* [6]; Ullah *et al.* [7]). Additionally, higher rates of N increase photosynthetic processes, leaf area production, leaf area duration as well as net assimilation rate (Ahmad *et al.* [8]; Munir, *et al.* [9]). The increase the individual leaf area and total leaf area of crop plants are helpful to increase the grain yield(Cheema *et al.* [10]; Tsialtas and Maslaris [11]; Rafiq *et al.* [12]). Many researchers (Miralles *et al.* [13]; Bange [14]) concluded that N increases grain yield by affecting the growth and development of sunflower. In Pakistan cultivation of exotic sunflower hybrids are not good for better yield because these are not well adapted to our agro climatic conditions. Therefore, introduction of such hybrids which are early maturating, having high oil contents and producing high seed yield under summer temperature and drought conditions (Bakht *et al.* [15]). There is lack of advanced production technology and farmers are facing acute problems in growing sunflower crop in Pakistan. Therefore the present study was conducted with the objective to evaluate the effect of different nitrogen rates on growth, grain yield of different sunflower hybrids under ecological conditions of Sargodha, Punjab-Pakistan.

2. Materials and Methods

2.1. Experimental Site and Soil

The experiment was conducted at the Agronomic Research Area of, University of Sargodha (32˚05''N, 72˚67''E), Pakistan during the spring seasons of 2013. The soil is sandy clay loamy somewhat poorly drained with pH ranging from 7.9 - 7.33. The nitrogen level was 0.066 to 0.052 are shown in **Table 1**.

2.2. Design and Treatments

The experiment was set in a Split plot arrangement under RCBD having 3 replications. The net plot size was 4.2 m × 6 m having row to row spacing 70 cm and plant to plant distance 20 cm. Sunflower hybrids (Hysun-33, S-278) were kept in main plots and N levels (0, 45, 90,135 and 180 kg/ha) in sub plots. The crop was sown by dibbler method using seed rate of 5 kg/ha. Phosphorus and potash were applied at the rate of 80 - 40 kg/ha in all plots. Nitrogen, Phosphorus and potassium were used in the form of urea, DAP and Potassium (K_2SO_4). The nitrogen

Table 1. Physico-chemical soil analysis of crop area.

Characteristic	Soil sample depth			
	10 cm	15 cm	20 cm	Mean
Soil pH	7.9	7.9	8.0	7.33
Organic Matter (%)	1.32	1.32	1.04	1.22
Total Nitrogen (%)	0.066	0.066	0.052	0.061
Available P ($mg \cdot kg^{-1}$)	4.6	7.5	10.2	7.43
Available K ($mg \cdot kg^{-1}$)	188	164	144	165.33
Texture	Sandy loam	Sandy loam	Sandy loam	

was used in three splits, 1/3 dose of nitrogen and all of the phosphorous and potash fertilizer were applied at the time of sowing. Remaining 2/3 of nitrogen was used in two splits, at first irrigation and flowering stage. All other agronomic practices such as hoeing, weeding, irrigation and plant protection measure were kept normal for the crop.

2.3. Plant Sampling and Measurements

A sample of 5 plants were selected randomly from each plots for measuring growth parameters such as leaf area index, leaf area duration. At final harvest 10 plants fortnightly were selected form each plots for measurement of days to maturity, number of achene's per head, 1000-achene weight(g), achene's yields (kg/ha) and total dry matter (kg). First growth sampling was conducted after 15 days of sowing, then each sampling every 10 days interval. The leaf area was measured from 10 g fresh leaves from harvested material from each fifteen days interval. An area meter (CI 202. Portable Laser Leaf Area Meter) was used for the measurement of leaf area.

2.4. Statistical Analysis

Data collected on growth and yield components was analyzed statistically by employing the Fisher's analysis of variance technique and significant of treatment means was tested using least significance difference (LSD) test at 5% probability level (Steel *et al.* [16]) Calculating Root Mean Square error Value (RMSE) *i.e.* Residual variation among observed and stimulated data tested accuracy of model.

3. Growth Parameters

3.1. Leaf Area Index (LAI)

Leaf area index is the ratio of leaf area per unit land area. It is unit less quantity due to ratio of same units. Greater the leaf area index, increase the capability of plants to harvest the solar energy and converted into chemical energy. The two sunflower hybrids were statistically different from each other, maximum leaf area index (3.88) was observed in hybrid Hysun-33 as compared to S-78 (3.62) as

shown in Table 1. Same results are reported by (Kho [17]; Aleman *et al.* [18]). Leaf area index was significantly increased ranging 3.05 to 4.52 with higher supply of nitrogen fertilizer from 0 to 180 kg·ha^{-1} respectively. The application of nitrogen 180 kg·ha^{-1} attained the highest leaf area index (4.52), followed by N_4 (135 kg N ha^{-1}) treatment 4.26. The leaf area index (3.05) was achieved without use of nitrogen fertilizer and it was statistically at par with the plot where nitrogen was applied at the rate 45 kg·ha^{-1} (3.23). These findings were in close conformity with result of Nasim *et al.* [19]) who reported that increase leaf area index with enhancing the nitrogen levels. The statistically significant results were also observed during the interaction between hybrids and different nitrogen levels as shown in Table 2, nitrogen application 180 kg·ha^{-1} in hybrid Hysun-33 attained maximum leaf area index (4.76) statistically at par with same application level of S-78 (4.27). The lowest leaf area index (2.95) was recorded where no application of nitrogen fertilizer.

Figure 1 represents that leaf area index significantly affected by different nitrogen levels with hybrid Hysun-33. In all nitrogen treated plots LAI was enhanced with increasing the nitrogen levels. Maximum leaf area index (4.7) was attained by hybrid Hysun-33 with nitrogen level of 180 kg·ha^{-1} on 70 days and lowest (3.2) was recorded in control treatment. The leaf area index was increased in all fertilized nitrogen treated plots by applying of various levels with S-78 hybrid was shown in Figure 2. Show that highest leaf area index (4.4) was achieved by hybrid S-78 with nitrogen level of 180 kg·ha^{-1} on 70 days and lowest (2.95) was noted in treatment where no nitrogen was applied.

3.2. Leaf Area Duration (Days)

Data reported in Table 2 demonstrated that Leaf area duration was statistically significant for different hybrids. The maximum leaf area duration (172.47) was

Table 2. Effect of hybrids and nitrogen levels on LAI. LAD. DA. DM. HD. NAH. AY and TDM.

Treatment	L.A.I	L.A.D	D.A	D.M	H.D	N.A.H	A.Y	T.D.M
H_1 = Hysum-33	3.88 a	172.47 a	69.93 a	120.07a	16.25 b	917.3 b	3464.4 b	9747.2 a
H_2 = S-78	3.62 b	154.0 b	58.86 b	102 b	21.98 a	1054.9 a	3714.8 a	8593.7 b
Tukey HSD		6.09	4.14	2.35	1.14	25	128	594.05

Nitrogen Levels	L.A.I	L.A.D	D.A	D.M	H.D	N.A.H	A.Y	T.D.M	A.Y	T.D.M
N_1 = 0 kg·ha^{-1}	3.055d	127.75 e	62.50d	108.17c	16.06c	767.5c	3067.8c	7645c	3067.8c	7645c
N_2 = 45 kgha^{-1}	3.236d	141.98d	63.33cd	109.83bc	17.18c	887.5bc	3242.5c	8103c	3242.5c	8103c
N_3 = 90 kg·ha^{-1}	3.686c	160.73c	64.33bc	110.67b	19.18b	954.7b	3652.5b	9140b	3652.5b	9140b
N_4 = 135kg·ha^{-1}	4.266b	187.40b	65.33ab	112.67a	21.15a	1121.8a	3970.2	10310a	3970.2a	10310a
N_5 = 180kg·ha^{-1}	4.521a	198.33a	67.50a	114.67a	22.01a	1199.2a	4015.0a	10655a	4015.0a	10655a
Tukey HSD	0.227	4.52	1.17	1.73	1.47	121.41	214.6	803.59	214.6	803.59

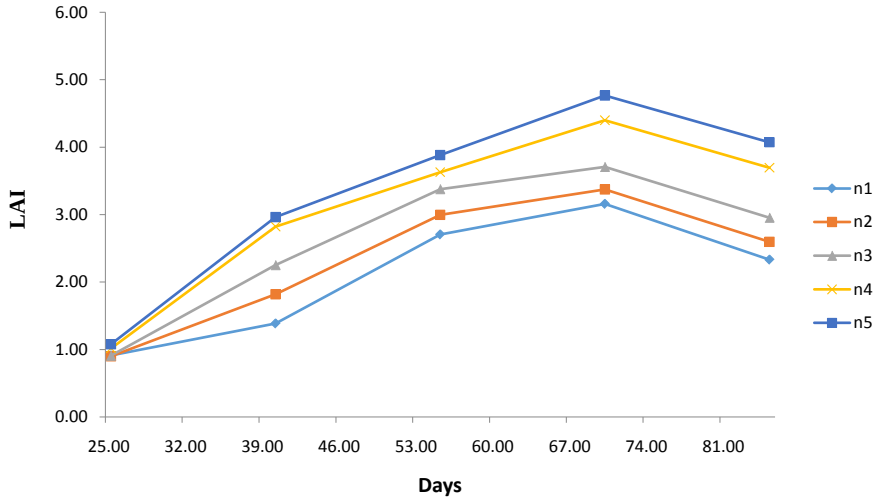

Figure 1. Effect of nitrogen on leaf area index of Hysun-33.

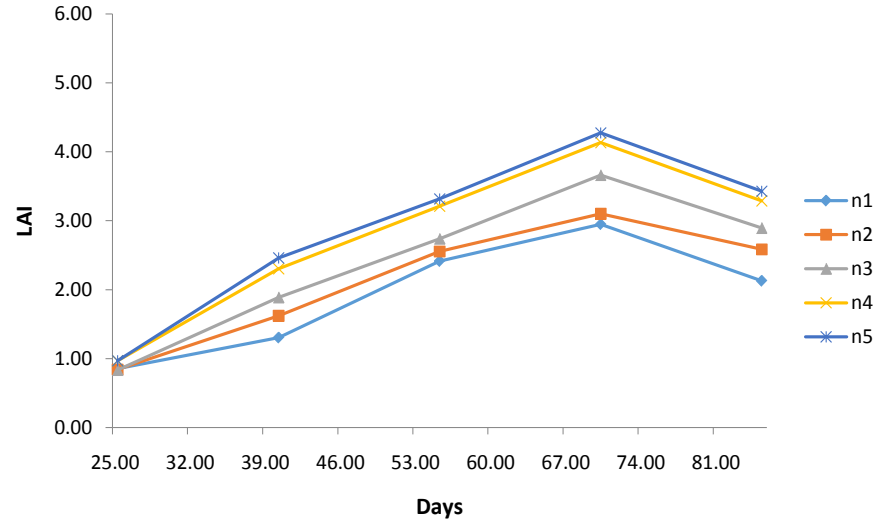

Figure 2. Effect of nitrogen on leaf area index of S-78.

recorded in Hysun-33 as compared to S-78 hybrid (154). Applying different levels of nitrogen fertilizer, the maximum leaf area duration (198.33) was observed in N_5 treatment (180 kg N ha^{-1}), followed (187.40) by the Treatment N_4 (135 $kg{\cdot}ha^{-1}$). However, the minimum leaf area duration (127.75) was recorded in control plots. These results are in close agreement with the finding of and also was same results (Albrizio *et al.* [20]) who concluded that leaf area duration was increase by enhancing the nitrogen application level.

The interaction between hybrids and nitrogen application affecting the leaf area duration was significant as shown in Table 3. Maximum leaf area duration (212.83) was noted in H_1N_5 combination which was followed by same hybrid at nitrogen level of 135 $kg{\cdot}ha^{-1}$ having LAD of 198.15. Hybrid S-78 attained maximum leaf area duration (183.83) at rate of nitrogen 180 $kg{\cdot}ha^{-1}$ which was statistically at par with nitrogen level 135 $kg{\cdot}ha^{-1}$ of same hybrid achieved LAD 176.65.

Table 3. Interaction between hybrids and nitrogen levels affecting the LIA. LAD. D M. HD. NAH. AY and TDM.

Treatment	L.A.I	L.A.D	D.M	H.D	N.A.H	A.Y	T.D.M
H_1N_1	3.16ef	133.15fg	117.00d	13.80f	839.7de	2923.7e	7771de
H_1N_2	3.37def	149.08e	118.67cd	14.76ef	841.3de	3078.7de	8530cde
H_1N_3	3.71cd	169.15d	120.00bc	16.43de	867.cde	3500bcn	9726abc
H_1N_4	4.40ab	198.15b	121.67ab	17.46cd	960.3bcd	3884.7a	11123ab
H_1N_5	4.76a	212.83a	123.00a	18.80cd	1077.7b	3935a	11586a
H_2N_1	2.95f	122.35 g	99.33 g	18.33cd	695.3e	3212cde	7519e
H_2N_2	3.10f	134.88f	101.00fg	19.60bc	933.7bcd	3406cd	7676de
H_2N_3	3.66de	152.30e	101.33fg	21.93b	1041.7bc	3805ab	8555cde
H_2N_4	4.13bc	176.65cd	103.67ef	24.83a	1283.3a	4055.7a	9496bcd
H_2N_5	4.27abc	183.83c	105.33e	25.23a	1320.7a	4095a	9723abc
Tukey HSD	0.3820	7.61	2.48	2.48	204.12	360.9	2358.2

Mean having different letters differ significantly from each other by Tukey HSD (P = 0.05).

4. Yield Parameters

4.1. Days to Anthesis (R.5.3 Stage)

The penology of crop plants is an important yield contributing parameter. The different sunflower hybrids have taken varying number of days to anthesis (R.5.3) stage. Hybrid hysun-33 took more days to R.5.3 stage (70 days) as compared to S-78 hybrid (59 days) as shown in **Table 2**. Difference for days to anthesis among hybrids was also observed by (Akhtar [21]; Nasim [22]; Ali *et al.* [23]). In all the treated plots with nitrogen, days to anthesis were significantly different over control. The 180 kg N ha^{-1} application significantly increases days for anthesis than 135, 90, 45, 0 kg N ha^{-1}. Nitrogen levels at the rate of 135, 90, 45 kg·ha^{-1} took 65, 64.16, 63.33 days for completion of 80 % anthesis which were statistically at par with each other. These results are supported by the findings of (Sadras [24]; Cechin *et al.* [25]). The interaction between hybrids and nitrogen levels for R.5.3 stage was non-significant.

4.2. Days to Maturity (R.9 Stage)

The maturity of plant plays important role for obtaining the highest yield of crop. Data (**Table 2**) indicate that plant maturity was significantly affected by different hybrids and nitrogen levels. The two sunflower hybrids were statistically different from each other. Hysun-33 taken more days to maturity (120 Days) as compared to S-78 (102 days). The similar result was observed from (Bakht *et al.* [15]; Bakht *et al.* [26]). The plant maturity was enhanced by different levels of nitrogen fertilizer application. The 180 and 135 kg N ha^{-1} showed at par effect on days to plant maturity. The lowest number of days for R. 9 was recorded in control plot. These results are close agreement with (Bakht *et al.* [15]) also observed that plant maturity was enhance with increasing the nitrogen rates.

The statistically significant results were observed during the interaction between hybrids and varying nitrogen rates. The data in Table 3 showed that more no of days (123) was required to plant maturity in hybrid Hysun-33 with treatment level of 180 kg Nha^{-1} at par with 135 kg N ha^{-1} (121). The S-78 hybrid was observed in treatment H_2N_5 and H_2N_4 with nitrogen level of 180 and 135 kg·ha^{-1}, required days 105 and 103 respectively. These are statistically at par with each other.

4.3. Head Diameter (cm)

Head diameter is an important character indicating the plant yield. Data in Table 2 presents that head diameter was significantly affected by different sunflower hybrids as well as different levels of nitrogen fertilizer. The hybrid S-78 produced significantly greater size of head diameter (21 cm) as compared to Hysun-33 (16 cm).Head diameter was enlarged with increasing the rates of fertilizer from 0 to 180 kg N ha^{-1}. The maximum size of head diameter (22 cm) was recorded in treatment N_5 (180 kg N ha^{-1}) and it is statistically at par with nitrogen rate of 135 kg·ha^{-1}The lowest head diameter (16 cm) was noted in treatment N_1 the control plots. The statistically significant results were also observed during the interaction between hybrids and different nitrogen levels. The data in Table 3 exhibited that highest head diameter 25 cm and 20 cm of S-78 hybrid was observed in treatment H_2N_5 and H_2N_4 with nitrogen level of 180 and 135 kg·ha^{-1}, respectively. The Hysun-33 hybrid with same level of Nitrogen 180 and 135 kg·ha^{-1} produced smaller head diameter of 18 cm and 17cm respectively, which was statistically at par with the control treatment of S-78. These results are supported by the findings of Khaliq and Cheema [27].

4.4. Number of Achene's Per Head

The data regarding number of achene's per head is given in Table 2 exhibited that hybrid S-78 produced more numbers of achene per head (1054) as compared to Hysun-33 (917) which were statistically different from each other. Number of achenes per head was significantly increased with higher nitrogen fertilizer rates. The application of 180 kg N ha^{-1} produced highest number of achenes per head (1199) and it is statistically at par with the plot where nitrogen was applied at the rate 135 kg·ha^{-1}. The lesser number of achenes per head (767) was recorded in control treatment. The interaction between hybrids Hysun-33 and S-78 with varying levels of nitrogen was significant. Results presented in Table 3 revealed that highest number of achenes per head (1320) was noted in treatments N_5 (180 kg N ha^{-1}) and N_4 (135 kg N ha^{-1}), respectively, in S-78 hybrid. The same treatment N_4 (135 kg N ha^{-1}) for Hysun-33 produced 960 number of achenes per head which was statistically at par with the application of nitrogen fertilizer 45 Kg·ha^{-1} of hybrid S-78. These results are supported by the findings of (Nazir *et al.* [28]; Akhtar and Malik. [29]) who concluded that interaction between hybrids and nitrogen application was significant.

4.5. Achene Yield (kg·ha^{-1})

The most essential parameter is achene yield in sunflower crop and number of components are included for obtaining the highest yield are, head diameter, number of achenes per head and 1000 achene weight. The statistically significant results were observed between hybrids as shown in Table 2. The hybrid S-78 produced higher achene yield (3714 kg·ha^{-1}) than Hysun-33 (3464 kg·ha^{-1}). The data (Table 2) indicated that increased nitrogen levels promote the achene yield significantly. Among the nitrogen levels N_5 (180 kg·ha^{-1}) produced significantly higher achene yield (4015 kg·ha^{-1}), which was statistically at par with N_4 treatment where the yield obtained was 3970 kg·ha^{-1}. However, the lowest achene yield (3067 kg·ha^{-1}) was recorded in control treatment.

The interaction of hybrids and nitrogen application was found to be significant in Table 3. Maximum achene yield (4095 kg·ha^{-1}) was noted in H_2N_5 combination which was statistically at par with H_1N_4 (3884 kg·ha^{-1}) and H_2N_4 (4055 kg·ha^{-1}). The lowest achene yield was noted in hybrid Hysun-33 (2923) without application of nitrogen fertilizer. These results are in close agreement with the finding of (Khaliq and Cheema. [28]; Akhtar and Malik. [29]; Hussain *et al.* [30] who concluded that interaction was significant between hybrids and nitrogen application.

4.6. Total Dry Matter (kg·ha^{-1})

The data (Table 2) depict that total dry matter was significantly affected by different hybrids and applying of various nitrogen fertilizer levels. The total dry matter production of Hysun-33 hybrid was more (9747 kg·ha^{-1}) as compared with S-78 (8593 kg·ha^{-1}). As regards of different nitrogen fertilizer application levels, total dry matter production in all the fertilized plots was significantly higher than treatment receiving no fertilizer. The highest rate of nitrogen fertilizer (180 kg N ha^{-1}) showed the greatest total dry matter 10655 kg·ha^{-1} however this rate of nitrogen fertilizer was statistically in par with 150 kg N ha^{-1}. The plots was treated with nitrogen level 0 and 45 kg·ha^{-1} produced total dry matter (6745 and 8103 kg·ha^{-1}) respectively, which was statistically at par with each other.

The statistically significant interaction was observed between hybrids Hysun-33 and S-78 with varying levels of nitrogen affecting the total dry matter. The data in Table 3 concluded that Hysun-33 at 90 kg N ha^{-1} produced total dry matter (9726 kg·ha^{-1}), which was statistically in par with hybrid S-78 (9723 kg·ha^{-1}) at application of nitrogen level 180 kg·ha^{-1}. The highest total dry matter (11586 kg·ha^{-1}) noted in hybrid Hysun-33 with nitrogen application of 180 kg·ha^{-1} as well as lowest total dry matter was obtained from S-78 with least application of nitrogen fertilizer (control). The results are close with finding of (Nasim *et al.* [20]) who reported a significant interaction was between hybrids and nitrogen application. There was positive and strong liner relationship between total dry matter and achene yield with value of (R^2 = 0.41) shown in Figure 3.

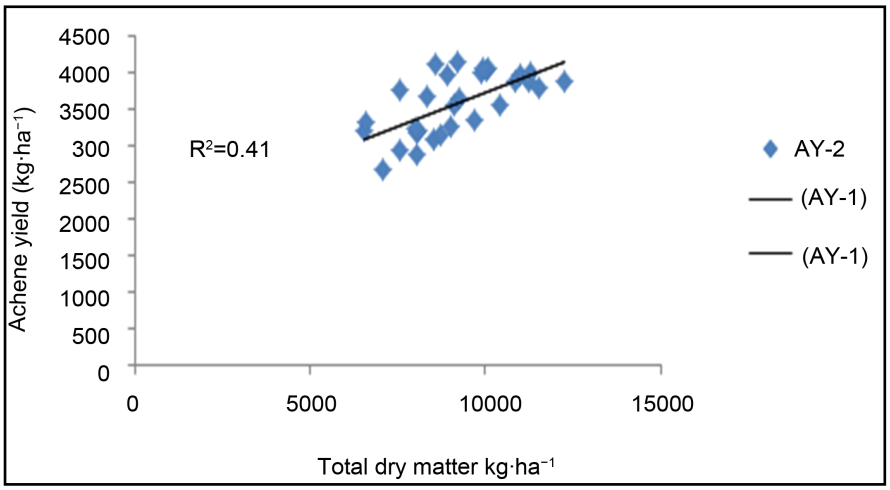

Figure 3. Relationship between Achene yield kg·ha^{-1} and Total dry matter kg·ha^{-1}.

5. Conclusion

The comparison of the different sunflower hybrids with varying nitrogen levels was evaluated for sunflower crop and it was concluded that N4 treatment (135 kg N ha^{-1}) with hybrid S-78 gave higher achene yield as compared to other nitrogen rates. Hence it is recommended that for maximum benefits, sunflower should be fertilized at 135 kg N ha^{-1}.

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