RESPONSE OF SUNFLOWER HYBRIDS TO DIFFERENT NITROGEN LEVELS FOR PHYSIOLOGICAL AND AGRONOMICAL TRAITS UNDER FIELD CONDITIONS

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ABSTRACT:- Sunflower occupies main position among oil seed crops in Pakistan. Mostly indigenous sunflower hybrids are cultivated which give low achene and fodder yields. The issue related with these hybrids ascribed to lack of information about use of inputs and cultural practices. Judicious nitrogen use and suitable high yielding hybrid play key role in increasing sunflower productivity. Protein is the basic requirement of the metabolic processes for the vegetative, reproductive growth and yield of the crop. The protein is wholly dependent upon the amount of nitrogen fertilization available in soil for the plant use. A two year study was conducted in 2012 and 2013 at National Agricultural Research Centre (NARC), Islamabad, Pakistan. The experiment was aimed to evaluate the effect of different nitrogen (N) levels (N_0 = 0 kgha^{-1}, N_1 = 60 kgha^{-1}, N_2 = 80 kgha^{-1}, N_3 = 120 kgha^{-1}, N_4 = 180 kgha^{-1} and N_5 = 240 kgha^{-1}) on two sunflower hybrids, SMH-0907 and SMH-0917 to optimize the N levels for obtaining maximum yield on sustainable basis. Both hybrids were kept in the main plot while N levels in the sub plot in a randomized complete block design with three replications. The results showed that the number of achene head^{-1}, 100-achene weight and achene yield increased with increased N application. The increased levels of N also enhanced the achene yield. The maximum achene yield (3170.8 kg ha^{-1}) was recorded at 180 kg N ha^{-1} followed by 240 kg N ha^{-1}. Minimum achene yield (2115 kg ha^{-1}) was observed in control treatment (N_0). Polynomial regression line showed that the rate of yield increase was higher up to 180 kg N ha^{-1} and become slow thereafter. The hybrid SMH-0907 produced more achene (2736 kg ha^{-1}) as compared to the hybrid SMH-0917 (2694 kg ha^{-1}). Results revealed that economized application of different doses of N can boost up the yield in both sunflower hybrids SMH-0907 and SMH-0917. These findings could be helpful in rationalizing most valuable inputs such as nitrogen in sunflower crop. It can be deduced that the application of 180 kg N ha^{-1} can provide the best combination for good yield in sunflower crop under the prevailing humid conditions of Pakistan.

Key Words: Sunflower; Hybrid; Achene Yield; Crop Growth Rate; Harvest Index; Leaf Area Index; Net Assimilation Rate; Irrigation Levels; Planting Methods; Pakistan.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an annual crop having a bulky flower capitulum. It is grown for oil, edible seed as well as for forage purposes. Sunflower was initially domesticated in North America and then it spread to other parts of the world. It is a short duration crop (95 days) maturity hence can be fitted in the current cropping pattern having short window for any incorpo-

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ration of short duration crop without considerable alteration. On the other hand having genotypic ability it can withstand wide range of temperature (17.8°-32.8 °C) (Mirshekari et al., 2012). Sunflower seed contains 40-50% oil and 17-20% protein (Bakhsh et al., 1999). In Pakistan sunflower was domesticated as oil seed crop in early sixties. At that time the total area under the crop was 670 ha with 480 t of total production. The area started to increase in 1980-81 but with considerable fluctuation on year to year bases (GoP, 1995). Sunflower is successfully grown in Pakistan under different soil/climatic conditions and cropping systems. It is mostly in rice (70%) and cotton (20%) growing areas. It is very interesting that sunflower production is almost double (1550-2000 kg ha^{-1}) in cottonsunflower area against 1000-1300 kg ha^{-1} in rice-sunflower growing areas that brings country's national average to 1250 kg ha^{-1}. Sindh is the province of Pakistan where maximum area, 60-88% of the total sunflower is grown in rice farming system.

Currently domestic edible oil production is 567 mt as compared to 2502 mt of oil which is imported @ Rs. 242 billion. (GoP, 2014). A number of biotic and abiotic factors are responsible for potential yield of a sunflower crop. A fertile soil provides all essential nutrients for a plant. As an important constituent of protein, N plays significant role in vegetative and reproductive growth causing increase in sunflower yield (Steer and Hocking, 1984). N have different role in plant such as it enhances photo-synthesis rate (Fayyaz-ul-Hassan et al., 2005). The increased N accumulation and dispersion into different plant parts will enhance the growth and development and ultimately increase the yield of crop (Khaliq and Cheema, 2005). They concluded that at certain level of fertility, additional doses did not further enhance the yield.

The present study is aimed to investigate the physiology and agronomic response of two sunflower hybrids to different nitrogen levels under field conditions.

MATERIALS AND METHOD

A randomized complete block design (RCBD) was adopted with split plot arrangement. Sunflower hybrids were kept in main plots and N levels were kept in sub-plots (Table 1). The treatments were repeated thrice. The experiment consisted of five N levels (0, 60, 120, 180 and 240 kg N ha^{-1}) and two sunflower hybrids namely, SMH-0907 and SMH-0917. Experimental field was also irrigated before seedbed preparation and field was ploughed 2-3 times, each followed by planking. The source of NPK was urea, single super phosphate and muriate of potash, respectively. Full dose of P and K (60 kg P_2O_5 and 120 kg K_2O ha^{-1}) was applied at planting time while N was divided into

Table 1. Arrangement of N levels

Treatments	Hybrid	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
T_1	SMH-0907	0	120	60
T_2	SMH-0907	60	120	60
T_3	SMH-0907	120	120	60
T_4	SMH-0907	180	120	60
T_5	SMH-0907	240	120	60
T_6	SMH-0917	0	120	60
T_7	SMH-0917	60	120	60
T_8	SMH-0917	120	120	60
T_9	SMH-0917	180	120	60
T_{10}	SMH-0917	240	120	60

two halves. One half was applied at planting time; remaining N was applied at first irrigation. The crop was planted on February 29, 2012 and March 14, 2013 through dibbler by dropping two seeds per hill. Total number of four irrigations was applied at seedling, buttoning, flowering and seed setting stages in both the experimental years. Standard agronomical practices and plant protection measures were followed. The meteorological data (temperature, pan evaporation rate, rainfall and relative humidity) were recorded during the experiment (Table 2). All meteorological data were obtained from the measurement made at the Meteorological Observatory at NARC .The soil samples were collected from the 0-15 cm profiles and analyzed. The soils are alkaline, non-saline and slightly to moderately calcareous (Table 3). The soil was loamy in texture.

Data was recorded on physiological (leaf area index at 40 and 65 days after sowing and harvest index) and agronomic (number of achene head^{-1}, 100-achene weight and achene yield) parameters.

Table 2. Meteorological data recorded during the experiment at 0800 h and 1400 h daily)

Months	Temperature (C°)		Pan Evap. (mm)	Rainfall (mm)	Avg. relative humidity (%)
	Max	Min			
2012					
January	16.9	1.3	1.30	59.1	68.5
February	17.4	3.2	1.80	44.1	70.1
March	24.9	8.9	3.30	16.0	58.6
April	29.9	15.0	4.70	40.9	54.7
May	36.2	18.3	7.30	9.5	39.0
June	40.9	22.7	10.40	4.5	31.2
July	36.9	24.1	6.70	198.0	59.0
2013					
January	17.3	2.45	38.71	17.25	79.2
February	17.4	6.46	38.62	274.40	80.6
March	25.3	10.5	84.20	85.86	74.0
April	29.2	14.5	133.50	36.07	63.8
May	36.6	18.5	230.40	22.15	46.0
June	37.8	22.9	213.60	102.88	59.0
July	34.3	23.7	148.60	280.71	79.0

Table 3. Soil characteristics of experimental field in 2012 and 2013

Soil property	2012	2013
pH	8.27	8.22
Ece (dSm^{-1})	1.09	1.08
K (mg kg^{-1})	107.60	103.20
Na (mg kg^{-1})	32.60	32.40
NO_3-N (mg kg^{-1})	0.81	0.63
P (mg kg^{-1})	2.19	2.17
OM (%)	0.84	0.82
HCO_3 (mg kg^{-1})	7.91	7.80
CI (mg kg^{-1})	1.80	1.81
Ca+Mg (mg kg^{-1})	14.25	13.46
Clay (%)	22.61	22.42
Silt (%)	31.42	29.60
Sand (%)	45.97	45.94
Texture class	Loam	

Physiological Parameters

Leaf Area Index (LAI) and Net Assimilation Rate (NAR)

Leaf area index (LAI) was measured with help of an electronic device MK_2 (Area measurement system, Delta T-Devices Ltd, Burwell Cambridge England). The dry weight was expressed in g m^{-2} day^{-1}) and was calculated using the following formula:

$$LAI = \frac{\text{Leaf area per plant (dm}^2\text{)}}{\text{Ground area covered by the plant (dm}^2\text{)}}$$

Harvest Index (HI)

Harvest index (HI) as the ratio of the seed yield to total biological yield (above ground biomass) was calcu-lated by following formula:

HI % = Seed yield/Biological yield

Agronomic Data

Number of Achene Head^{-1}, 100-Achene Weight (g) and Achene Yield (kg ha^{-1})

Ten head randomly selected to count for number of achene head^{-1}. The heads were randomly selected from central rows of each sub plot at maturity. For 100 achene weight, 100 achenes were randomly selected from seed lot and their weight was expressed in grams.

At maturity all heads were threshed manually from each sub-plot. Fresh seed yield of each plot was recorded and converted into kg ha^{-1}. Samples of seeds from each plot were taken randomly to assess moisture contents and dry weight was measured. The achene yield (AY) was determined as follows:

$$AY = \frac{\text{Dry weight of sample}}{\text{Fresh weight of sample}} \text{ x total weight x 1333.33}$$

Statistical Analysis

For statistical analysis Statistix 8.1 was adopted. Analysis of variance was used to measure variation among the treatments (Steel and Torrie, 1981) while the least significant difference was used to compare treatments. Differences among the mean values were separated by LSD for elucidation of the results. The polynomial regression analysis was done and optimum dose of nutrient elements for maximum achene yield and economic rate of inputs were calculated from simple polynomial regression equations:

$$Y = \alpha + \beta^2{}_1 x + \beta_2 x \text{ (Zaman et al., 1982)}$$

where,

x = Independent variable (N_2)
Y = Dependent variable (yield and other parameters)

RESULTS AND DISCUSSION

Response of Physiological Character to N Levels

Leaf Area Index (LAI)

Analysis of variance showed that all types of interactive effects were non-significant, however main effect of year hybrid and nitrogen level were highly significant ($P \leq 0.01$) on leaf area index at 40 days after sowing (Table 4). LAI of sunflower hybrid at 40 days after sowing was significantly increased with the increase of nitrogen

Table 4. Analysis of variance for effect of N levels on different parameters of sunflower during 2012 and 2013

source	DF	LAI 40	LAI 65	HI (%)	100 ACW	NO-ACH	ACY (kg)
N levels	4	0.4326**	14.6778**	44.2691**	19.4417**	132011**	2172143**
Hybrids	1	0.2281**	5.3402**	18.6484**	16.0167**	28733**	25503ns
Year	1	0.2281**	2.2042**	25.7022**	16.0167**	952ns	312049**
N levels x hybrids	4	0.0048ns	0.0429ns	1.9153**	0.475ns	3845**	60432*
N levels x Years	4	0.0031ns	0.2206**	0.4597**	0.5583ns	4470**	42554ns
Ybrids x years	1	0.0041ns	0.0202ns	0.1335ns	0.4167ns	7912**	105420*
N levels x hybrids x years	4	0.005ns	0.0848ns	0.104ns	0.125ns	1849**	24002ns
Error	40	0.0026	0.0347	0.076	0.2395	473	19909

LAI 40 = Leaf area index at 40 days after sowing, LAI 65 = Leaf area index at 65 days after sowing, HI = Harvest index, 100 ACW = 100-achene weight, NO-ACH = number of achenes per head and ACY = Achene yield
** and ** = Significant at 0.1 and 0.05 percent, respectively*

fertilizer. It was highest (0.81) with 180 kg N ha^{-1} followed by 240 kg N ha^{-1} (Figure 1a). It was lowest (0.33) at 40 days after sowing in control where no nitrogen was applied. Thus the response of LAI at 40 days after sowing was almost linear up to 180 kg N ha^{-1} but reverse trend was observed beyond that point. The polynomial regression analysis (Figure1a) showed a strong positive correlation (R_2=0.849) between nitrogen levels and LAI after 40 days of sowing. The effect of year at 40 days after sowing was highly significant ($P\leq 0.01$). Results showed 26% higher LAI at 40 days after sowing in 2013 than 2012 (Table 5). The hybrid SMH-0917 showed higher LAI at 40 days after sowing than the hybrid SMH-0907 (Table 6).

Interactive effect of N level x year was significant while all other such effects were non-significant (Table 4). The main effect of year, hybrid and nitrogen level were highly significant ($P\leq 0.01$) on LAI at 65 days after sowing. The LAI was significantly increased with the increase of nitrogen fertilizer up to 180 kg ha^{-1} and there was a decrease thereafter (Figure 1a). Results showed that the highest LAI (4.5) was recorded at 65 days. With the application of 180 kg N ha^{-1} as compared to 1.68 in control (Figure 1a). This shows 168% increase over control. The polynomial regression analysis also showed a strong positive correlation (R^2= 0.943) between nitrogen levels and LAI at 60 days after sowing. The higher LAI at optimum N level could be ascribed to the higher rate of cell division followed by enlargement

Table 5. Mean effect of years (2012 and 2013) on different parameters of sunflower

Years	LAI 40 Days	LAI 65 Days	HI (%)	100 ACW (g)	NO ACH	ACY (kg ha^{-1})
2012	0.50^{b}	3.07^{a}	13.07^{b}	5.035^{b}	773.20^{a}	2642.8^{b}
2013	0.63^{a}	3.45^{b}	15.07^{b}	6.07^{a}	765.23^{a}	2787^{a}

Means followed by same letter do not differ significantly.

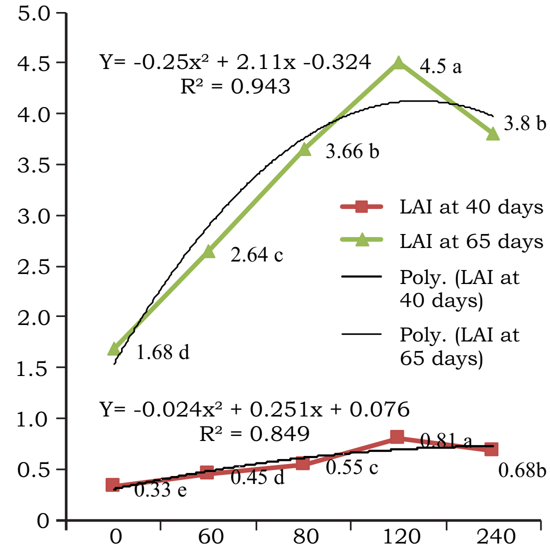

Figure 1a. Effect of N level on leaf area index

as reported earlier researchers (Bange et al., 2000; Cechin and Fumis, 2004). The overall finding showed that plant responded to nitrogen application and this response is proportional up to 180 kg N ha^{-1} and decreases further as nitrogen level increases (Figure 1a). Oliveira et al. (2012) reported that optimum nitrogen supply increases carbohydrate synthesis and utilization, hence promoting plant growth. Whereas with inadequate nitrogen the reverse phenomena of low carbohydrate synthesis and utilization results in slower growth of

Table 6. Mean performance of sunflower hybrids for different parameters during 2012 and 2013

Hybrids	SMH-0907	SMH-0917
LAI 40 Days	0.63^{a}	0.50^{b}
LAI 65 Days	3.56^{a}	2.96^{b}
HI (%)	14.97^{a}	13.67^{b}
100 ACW (g)	6.07^{a}	5.035^{b}
NO ACH	791.10^{a}	747.33^{b}
ACY (kg ha^{-1})	2735.5^{a}	2694.3^{a}

Means followed by same letter do not differ significantly.

vegetative cells.

The response of sunflower hybrids was also significant, as SMH-0907 showed 21% higher LAI at 65 days after sowing than SMH-0917. Year wise effect showed that LAI at 65 days was greater (12%) during 2013 as compared to 2012. This could be ascribed to the favorable weather conditions. Similar effect was also reported by Dar et al. (2009) who claimed that year (environment) had significant effect on LAI. These results are in conformity with Nasim et al. (2011) who observed that the growing conditions as well as season had significant effect on maximum LAI at 65 days after sowing throughout the growth.

Harvest Index(HI)

The interactive effect of N level x hybrid and N level x year was highly significant on harvest index (HI) whereas remaining types of interaction were non-significant. The main effect of nitrogen, year and hybrid were also highly significant (Table 4). All the five nitrogen treatments gave significantly different HI from each other. Polynomial regression line also confirmed that the rate of HI increase was higher up to 180 kg N ha^{-1} and become slower thereafter. Regression analysis also demonstrated a strong correlation (R^2= 0.984) between nitrogen application and HI (Figure 1b). The result showed that as nitrogen application is increased the HI goes on increasing which endorsed that more photoassimilates have been channelized into achene yield with increase in nitrogen application. This results in high HI. The increase in HI from 12% to 25% was observed with application of 60-120 kg N ha^{-1}. These results matched with those of Yasin et al. (2013) who reported significant response of HI to various N levels.

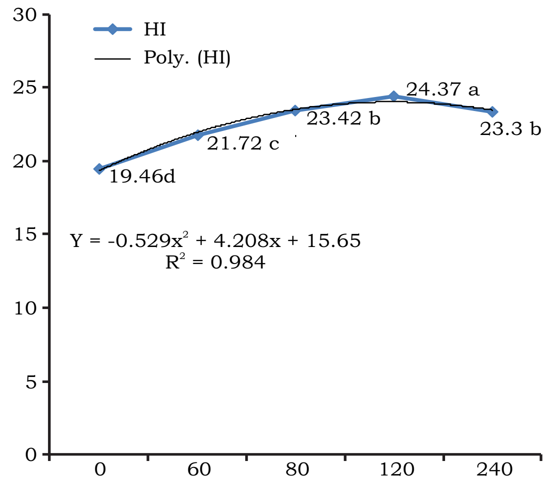

Figure 1b. Effect of N level on harvest index (%)

The HI was 6% greater in 2013 than 2012 (Table 6). Similarly, the hybrid SMH-0907 gave 5 % more HI than the hybrid SMH-0917 (Table 5). These results have show the relative dominance of SMH-0907 over SMH-0917 to utilize photo-assimilates into achene yield. Sinclair (1998) has also reported the approach of relative dominance in sunflower hybrid with respect to harvest index.

The effect of two way interaction of hybrid x N level on HI was highly significant. In hybrid × N interactions, maximum HI (24.86) was given by hybrid SMH-0907 with N level of 180 kg ha^{-1} while minimum HI (18.99) was attained by SMH-0917 from control plot without nitrogen application (Table 7).

Response of Agronomic Characters to N Levels

100 Achene Weight (g), Number of Achene Head^{1} and Achene Yield (kg ha^{-1})

Interactive effects of year x hybrid, N level x hybrid, N level x year and year x hybrid x N were non-significant on

Table 7. Response of interaction hybrid x N levels on different parameters of sunflower

N levels	Hybrids	LAI 40 days	LAI 65 days	HI (%)	100 AW	ACH	ACY (kg)
0	SMH-0907	0.38	1.95	19.94	4.17	644.3	2144.3
60	SMH-0907	0.50	3.01	22.63	5.50	710.5	2477.3
120	SMH-0907	0.63	4.03	23.91	6.67	815.3	2921.2
180	SMH-0907	0.90	4.58	24.86	8.00	944.0	3243.8
240	SMH-0907	0.73	4.21	23.72	6.00	841.3	2890.8
0	SMH-0917	0.28	1.41	18.99	3.50	638.8	2085.0
60	SMH-0917	0.40	2.26	20.82	4.33	668.0	2430.3
120	SMH-0917	0.48	3.3	22.93	5.33	744.0	2808.0
180	SMH-0917	0.73	4.43	23.88	6.50	851.3	3097.8
240	SMH-0917	0.63	3.4	22.87	5.50	834.0	3050.2

100- achene weight (Table 4). However, main effect of N level, hybrid and year was highly significant ($P \leq 0.01$) on 100-achene weight. All the nitrogen levels expressed significantly different effects on 100-achene weight from each other (Figure 2a). The polynomial regress-ion analysis showed that there was a strong positive correlation (R^2= 0.863) between nitrogen levels and 100-achene weight. The rate of 100-achene weight increased up to 180 kg N ha^{-1}

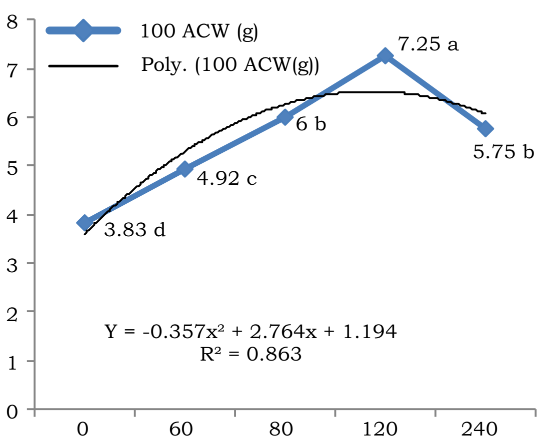

Figure 2a. Effect of N level on 100-achene weight (g)

and become slower subsequently. The highest 100-achene weighs (7.2 g) was obtained from the application of 180 kg N ha^{-1} followed by the application of 120 kg N ha^{-1} (6 g). This increase in 100-achene weight was 89% and 57%, respectively over control (3.85g). The hybrid SMH-0907 produced 21% (6.07g) higher 100-achene weight than SMH-0917(5.03 g) (Table 5). Therefore, hybrid SMH-0907 was comparatively more effective over SMH-0917 for 100-achene weight. Significantly greater 100-achene weight was harvested in 2013 than 2012 (Table 6). The increase in 100-achene weight was 21% (6.07 g vs. 5.03 g) in 2013 as compared to the 2012. These findings are also in line with those of Ghani et al. (2000), Zubillage et al. (2002), Killi (2004) and Abdel-Motagally and Osman (2010) who observed greater 100-achene weight with increased level of nitrogen application.

All interactive effects as well as main effects highly significantly affected the number of achene per head except the effect of year (Table 4). The two way interaction of year x hybrid showed that the maximum achene per head (799) were noted on hybrid SMH-0907 in 2013 whereas the minimum numbers of achene per head (732) were produced by hybrid SMH-0917 in the same year (Table 8). In hybrid x N fertilizer level interaction, the highest number of achene per head (944) was obtained by hybrid SMH-0907 with 180 kg N ha^{-1} while the least number of achene per head (639) was attained by hybrid SMH-0917 from control plot (Table 7). In three way interactions, year x hybrid x N level, the highest number of achene per head (946) was produced by hybrid SMH-0907 with 180 kg N ha^{-1} during the 2013 whereas the lowest number of achene per head (605) was produced by hybrid SMH-0917 during 2012 in control plot.

Results showed that number of achene per head increases as nitrogen application rate is increased, showing maximum number of achene per head (897) with application of 180 kg N ha^{-1} whereas the minimum number of achene per head (642) were harvested from the plots with no nitrogen application (Figure 2b). There is as much as 40% increase in number of achene per head over control where no nitrogen was applied. On the whole, nitrogen application showed an increase of 7-40% by application of 60-240 kg N ha^{-1} over the control. However, beyond 180 kg N ha^{-1}, there was a negative effect of N level on number of achene per head (Figure 2b). The polynomial line also revealed that the rate of nitrogen fertilizer increases the number of achene per head up to 180 kg N ha^{-1} and showed a negative effect afterward (Figure

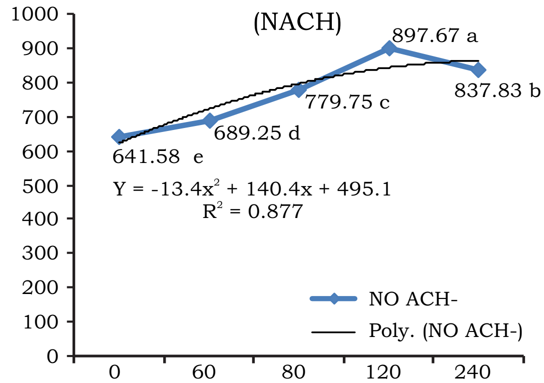

Figure 2b. Effect of N level on number of achene/head

2b). The regression coefficient also showed a highly positive correlation (R^2= 0.877) between the nitrogen rates and number of achene per head. The increase in number of achene per head may be attributed to more vegetative growth and viability of achene (seed setting) due to nitrogenous fertilizer. These results are also in line with those of Killi (2004) and Oliveria et al. (2012) who also claimed that the higher nitrogen rates significantly increases the number of achene per head. The nitrogen affects number of achene per head by influencing a number of growth parameters such as LAI, plant height, growth rate etc and thus more vigorous growth and development (Bindra and Kharwara, 1992 and Sarmah et al., 1992). Number of achene per head has an important role as part of final achene yield. Yasin et al. (2013) reported that number of achene per head is an important yield component which contributes materially towards final achene yield of sunflower.

The effect of interaction such as

Table 8. Response of interaction Hybrid x Years on different parameters of

Hybrids	Years	LAI 40 days	LAI 65 days	HI (%)	100 AW	NO-ACH	ACY (kg)
SMH-0907	2012	0.56	3.38	14.2	5.47	783.6	2621.5
SMH-0907	2013	0.7	3.73	15.73	6.67	798.6	2849.5
SMH-0917	2012	0.45	2.75	11.93	4.6	762.8	2664.1
SMH-0917	2013	0.56	3.17	14.4	5.47	731.87	2724.5

year x N level and N level x hybrids x year did not significantly affect achene yield of sunflower hybrids (Table 4). However the effect of interaction of year x hybrid and hybrid x N level significantly affected the achene yield. This shows that the sunflower hybrids response differently to various levels of N under different environmental conditions for yield. For example the highest achene yield (3243.8 kg ha^{-1}) was produced by the hybrid SMH-0907 with 180 kg N ha^{-1} while the lowest achene yield (2085 kg ha^{-1}) was produced by the hybrid SMH-0917 at control (Table 7). Similarly, the highest achene yield (2850 kg ha^{-1}) was produced by the hybrid SMH-0907 during 2013 whereas the lowest yield was also harvested from the same hybrid during 2012 (Table 8). Abdel-Motagally and Osman (2010) also reported the differential response of sunflower genotypes to different N levels and environmental conditions.

Results showed that the effects of nitrogen and year were highly significant and effect of hybrid was non-significant (Table 4). There was significant difference between nitrogen levels for achene yield (Figure 3). The maximum achene yield of 3170 kg ha^{-1} was achieved at the application of 180 kg N ha^{-1} which is almost double yield over control (2114.7 kg). The polynomial regression analysis (Figure 3) revealed that there is a strong positive correlation (R^2= 0.9752) between N application and achene yield. The calculated optimum level of N for maximum yield is 180 kg ha^{-1}. However, increasing of N level beyond 180 kg ha^{-1} causes reduction in the achene yield. The data reveals that the optimum level of N improves sunflower plant growth with a vigorous growth rate, high leaf area index, more number of achene per head and 100-achene weight which results in increase of the achene yield. Many earlier workers such as Ghani et al. (2000), Zubillage et al. (2002) Killi (2004) and Abedel-Motagally and Osman (2010) also reported greater response in achene yield with nitrogen application. They viewed that the favorable level of N levels increased the size and number of leaves which increase LAI. Thus higher photosynthetic rate and more favorable condition led to a good seed setting and higher 100-achene weight which in turn increased achene yield.

It can be thus deduced that the

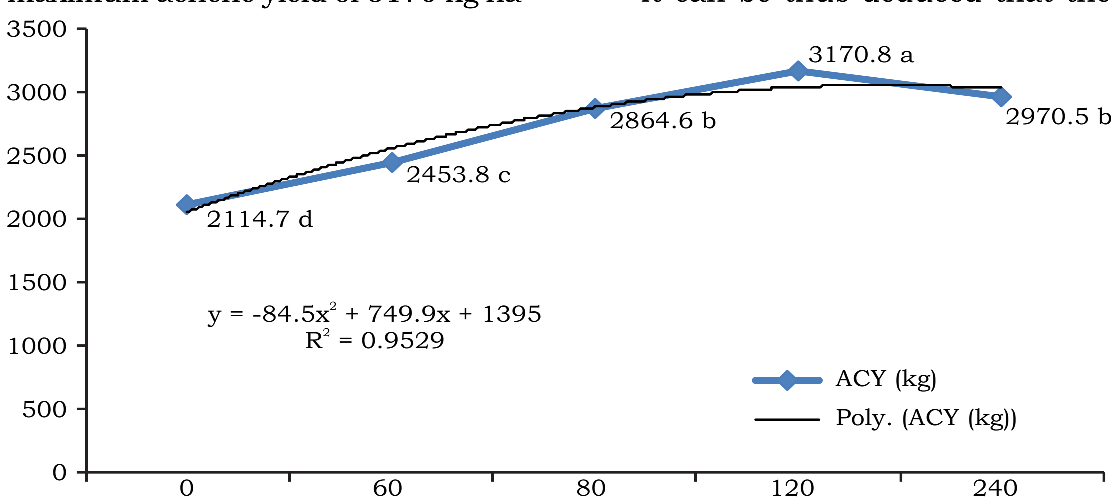

Figure 3. Effect of N level on achene yield kg ha^{-1})

sunflower hybrids response differently towards different N levels and environmental conditions. However, optimum N level increases achene yield and beyond that level there is a negative effect on achene yield of sunflower. Under agro-ecological condition of Islamabad the application of 180 kg N ha^{-1} is the optimum level for achieving the maximum achene yield.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

S. No	Author Name	Contribution to the paper
1.	Mr. Doulat Baig	Wrote abstract, Methodology, Data entry in SPSS and analysis, Result and discussion, Introduction, References
2.	Mr. Fida Mohammad Abbasi	Conceived the idea, Overall management of the article
3.	Mr. Habib Ahmed	Technical input at every step
4.	Dr. Maqsood Qamar	Did SPSS analysis
5.	Dr. Muhammad Ayub Khan	Data collection

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