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EFFECT OF NITROGEN ON GROWTH AND YIELD OF SUNFLOWER UNDER SEMI-ARID CONDITIONS OF PAKISTAN

WAJID NASIM[1,2,3*], ASHFAQ AHMAD[1], HAFIZ MOHKUM HAMMAD[1], HASSAN JAVED CHAUDHARY[2] AND MUHAMMAD FAROOQ HUSSAIN MUNIS[2]

[1]*Agro-Climatology Laboratory, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan.*
[2]*Department of Plant Sciences, Quaid-i-Azam University, Islamabad-45320, Pakistan,*
[3]*Current Address: Department of Environmental Sciences, COMSATS Institute of Information Technology (CIIT), Off Multan road, Mailsi road, Vehari-61100, Pakistan.*
**Corresponding author: wajidnaseem2001@gmail.com, wajidnasim@ciitvehari.edu.pk, Tel: 0092 333 991 1881.*

Abstract

Two years field study was carried out with the objective to determine the effect of different levels of nitrogen (N) on growth, development, yield and yield components of sunflower (*Helianthus annuus* L.) hybrids under agro-climatic conditions of Faisalabad-Pakistan in spring 2008 and 2009. The experiments were laid out in randomized complete block design with split plot arrangement keeping hybrids in the main plots and N levels in the subplots with three replications. The net plot size was 4.2 m x 5.0 m. The results indicated that with increasing N rates, there was also increment in the total dry matter (TDM), grain yield and yield components while the oil content was negatively affected. There was higher grain yield during 2008 as compared to 2009, probably due to more rainfall in the formation of TDM than in the latter stages. Hysun-38 hybrid gave maximum TDM (13.51 t ha^{-1}) and maximum grain yield (3.08 t ha^{-1}). Minimum TDM (11.94 t ha^{-1}) as well as grain yield (2.92 t ha^{-1}) was observed from Hysun-33. Among different N rates, 180 kg ha^{-1} gave maximum TDM at 14.02 t ha^{-1} and achene yield at 3.57 t ha^{-1} than other N rates. Maximum oil content (41.9%) was resulted from Hysun-38 without application of N fertilizer and minimum oil content (38.4%) was observed from N_5 treatment where 240 kg N ha^{-1} was applied. It was concluded that Hysun-38 with 180 kg N ha^{-1} proved to be better for good yield of sunflower crop under the prevailing semiarid conditions.

Introduction

Sunflower (*Helianthus annuus* L.) is an important oilseed crop which ranks 3rd after soybean and peanut along with other oil seed crops like (canola, and cotton) which contributes considerably to edible oil in the world (Thavaprakash *et al.,* 2002). 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.,* 2003). 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.,* 2006; Arshad *et al.,* 2009). In Pakistan, total area under cultivation is 506, 000 ha and production from this area is 755, 000 tons (seed) with average yield of 1.6 t ha^{-1} (Anon., 2009).

N play an imperative role in maximization of crop yields (Massignam *et al.,* 2009) and improves the yield as well as quality of all crops (Bell *et al.,* 1995; Dreccer *et al.,* 2000; Ullah *et al*., 2010). Additionally, higher rates of N increases photosynthetic processes, leaf area production, leaf area duration as well as net assimilation rate (Ahmad *et al.,* 2009; Munir *et al.,* 2007). The development of individual leaf area and total leaf area of crop plant and ultimately contributing towards higher grain yield (Cheema *et al*., 2001; Tsialtas & Maslaris, 2008; Rafiq *et al*., 2010). Many researchers (Miralles *et al.,* 1997; Bange *et al.,* 2000) concluded that N increases grain yield by affecting the growth and development of sunflower.

There is lack of advanced production technology and farmers are facing acute problems in growing sunflower crop in Pakistan. The present study was, therefore, conducted with the objective to evaluate the effect of different N rates on growth, grain yield and achene oil quality of different sunflower hybrids under ecological conditions of Faisalabad, Punjab-Pakistan.

Materials and Methods

Experimental site and soil: A field study was conducted at Agronomic Research Area, University of Agriculture, Faisalabad (31°.40" N, 73°.11" E) during spring 2008 and 2009 growing seasons. The soil is sandy clay loam according to USDA classification (Anon., 1998). Its color is brown, somewhat poorly drained, with pH ranging from 7.8-8.8 in the whole profile.

Design and treatments: The experimental design was randomized complete block design with split plot arrangement having three replications. The net plot size was 4.2 m x 5.0 m. The experimental site was prepared to form ridges with spacing 70 cm apart. The crop was sown at recommended seed rate of 7 kg ha^{-1} in second week of February 2008 and 2009 with hand mounted seed drill placing 3 seeds per hill and keeping 20 cm plant x plant distance. The hybrids were kept in main plots while different N levels were kept in sub plots. Treatments were five N levels (0, 60, 120, 180 and 240 kg ha^{-1}) and three sunflower hybrids (Hysun-33, Hysun-38 and Poineer-64A93). All phosphorus (P) and potassium (K) at the rate of 60 kg ha^{-1} was applied at the time of seed bed preparation in all plots. NPK were applied in the form of Urea, Triple Super Phosphate and Sulphate of potash (K_2SO_4). N fertilizer was used in different splits at critical stages of crop. All cultural practices (e.g., hoeing, weed management, irrigation, plant protection measures etc.) were kept normal for the crop during both years.

Sampling and measurements: A sample of 5 plants was selected in each plot fortnightly for measuring growth parameters. Like leaf area index, net assimilation rate, crop growth rate accumulation and total dry matter. At final harvest, 5 heads were selected for the determination of different yield components such as head diameter (cm), number of grains head^{-1}, 1000 grain weight and grain yield (kg ha^{-1}) was determined. The harvest index (HI) was calculated as the ratio of grain yield by total dry matter at harvest. The oil contents were determined by soxhlet fat extraction method (Miner *et al.*, 1995).

The environmental conditions for sunflower productivity were favorable, however, there was difference of environmental conditions in both years; spring season 2008 was cooler while spring season 2009 was hotter All the weather data (minimum and maximum temperature, relative humidity, rainfall, solar radiation) obtained from the measurement made at the nearest meteorological observatories around the experimental site. Fig. 1 indicates monthly means of weather elements during 2008 and 2009. Faisalabad (Usman *et al.*, 2009) was found to be medium from climatic point of view and was considered as cooler with minimum temperature and maximum rainfall especially during experimental year 2008, Rainfall was experienced more during spring 2008 than spring 2009 growing seasons: with average of 140 mm in 2008 and 73.80 mm during 2009, respectively (Usman *et al.*, 2010). Solar radiation received varied at 23.5-30.0 MJ m^{-2}d^{-1} during 2008 and minimum solar radiation during 2009, respectively (Fig. 1).

Statistical analysis: The data collected were statistically analyzed by using the computer statistical program MSTAT-C. Analysis of variance technique was employed with the least significance difference (LSD) test at 5 % level to compare treatments means (Steel *et al.*, 1997).

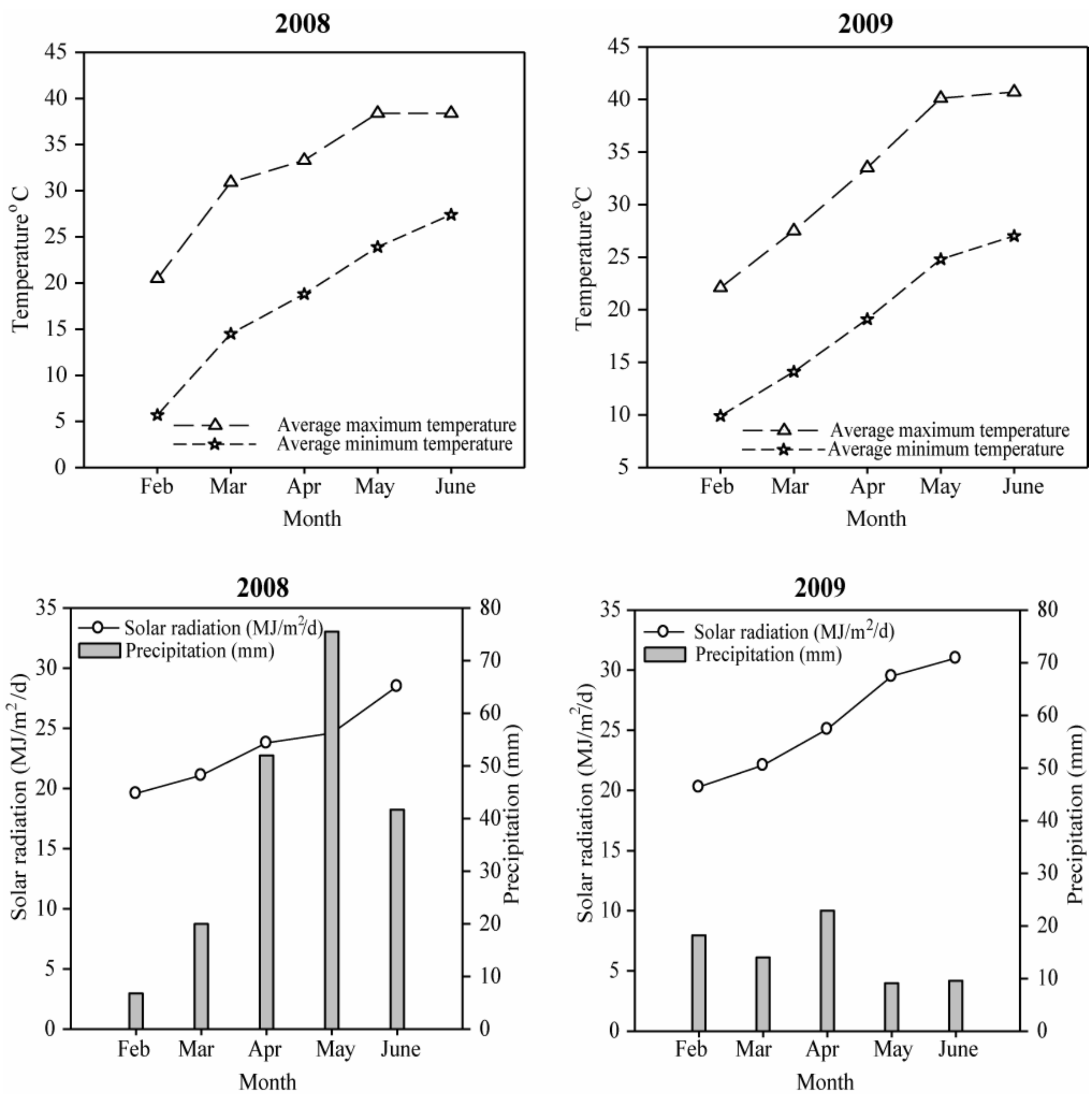

Fig. 1. Mean monthly environmental conditions (Max. and Min. temperature, solar radiation and precipitation) during 2008 & 2009.

Results

Crop growth analysis

Leaf area index: The year effect on LAI was significant; all treatment the crop had greater LAI in 2008 (4.0) than 2009 (3.8). Differences in LAI between hybrids were non-significant during both the years of experiments (Fig. 2). Maximum (4.4) LAI was produced by Hysun-38 which was statistically at par with Pioneer-64A93 (4.3) and minimum (3.7) LAI was given by in Hysun-33 (Fig. 2). The nitrogen rates also showed significant effect on LAI during the season; (Fig. 3). Maximum LAI was reached, when the crop was at 65 DAS; thereafter, it decreased in all N rates. N_4 (180 kg N ha^{-1}) treatment was statistically at par with N_5 (240 kg N ha^{-1}) treatment and minimum LAI was observed in N_1 (0 kg N ha) treatment (Fig. 3).

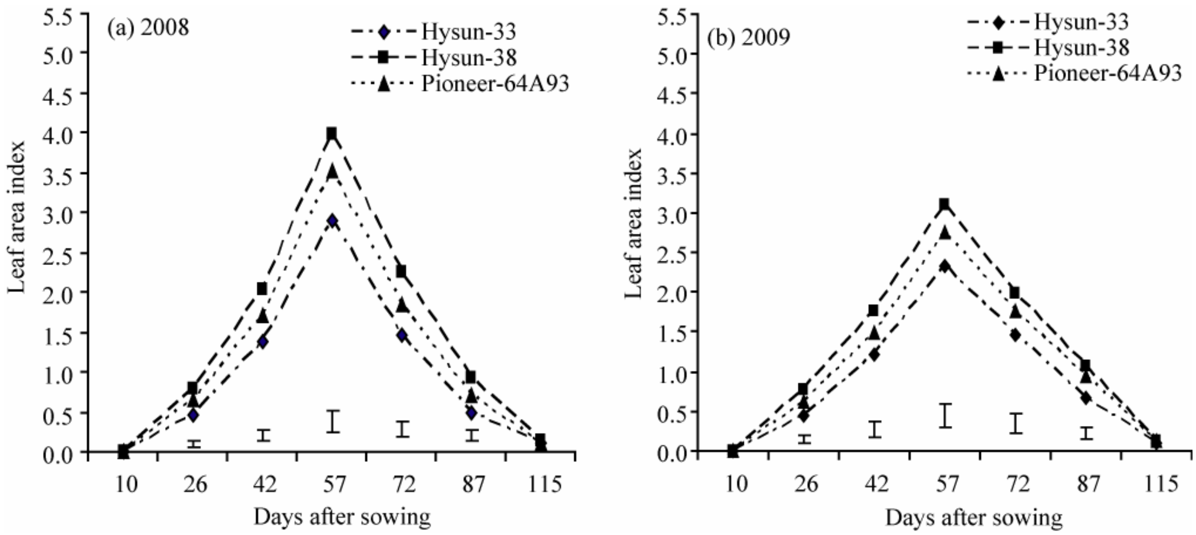

Fig. 2. Changes in leaf Area Index (LAI) during the crop cycle as affected by different hybrids during 2008 (a) & 2009 (b); Bars represent standard error of mean.

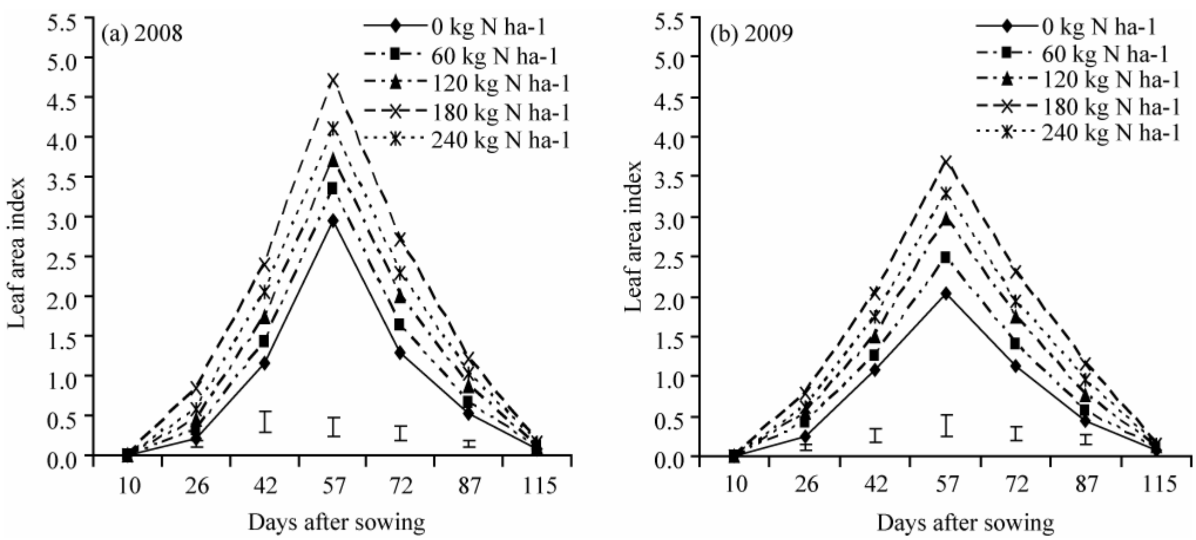

Fig. 3. Changes in leaf Area Index (LAI) during the crop cycle as affected by different nitrogen levels during 2008 (a) & 2009 (b); Bars represent standard error of mean.

Total dry matter: The Fig. 4 & 5 demonstrates seasonal effect on TDM accumulation of sunflower hybrids in both the years. Significantly maximum TDM was recorded in 2008 than 2009 growing season probably due to differences in environmental factors (Fayyaz-ul-Hassan *et al.*, 2005; Abbadi & Gerendas (2009). Maximum TDM (13510 kg ha^{-1}) was recorded by Hysun-38 followed by Pioneer-64A93 (12400 kg ha^{-1}) and minimum TDM (11940 kg ha^{-1}) was observed in Hysun-33, respectively. On average, the nitrogen fertilizer effect was positive on accumulation of TDM. The maximum TDM (14020 kg ha^{-1}) was observed in N_4 (180 kg N ha^{-1}) treatment followed by N_5 (240 kg N ha^{-1}) treatment (13455 kg N ha^{-1}) while minimum TDM (11180 kg N ha^{-1}) was observed in N_1 (0 kg N ha^{-1}) treatment, respectively (Fig. 5).

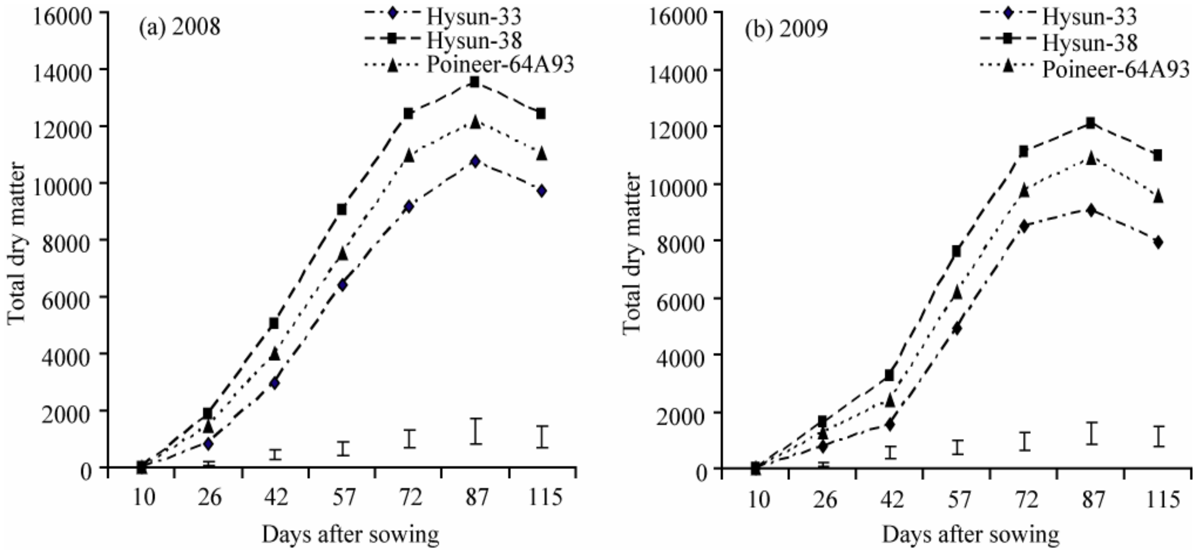

Fig. 4. Changes in total dry matter (kg ha^{-1}) during the crop cycle as affected by different hybrids during 2008 (a) & 2009 (b); Bars show standard error of mean.

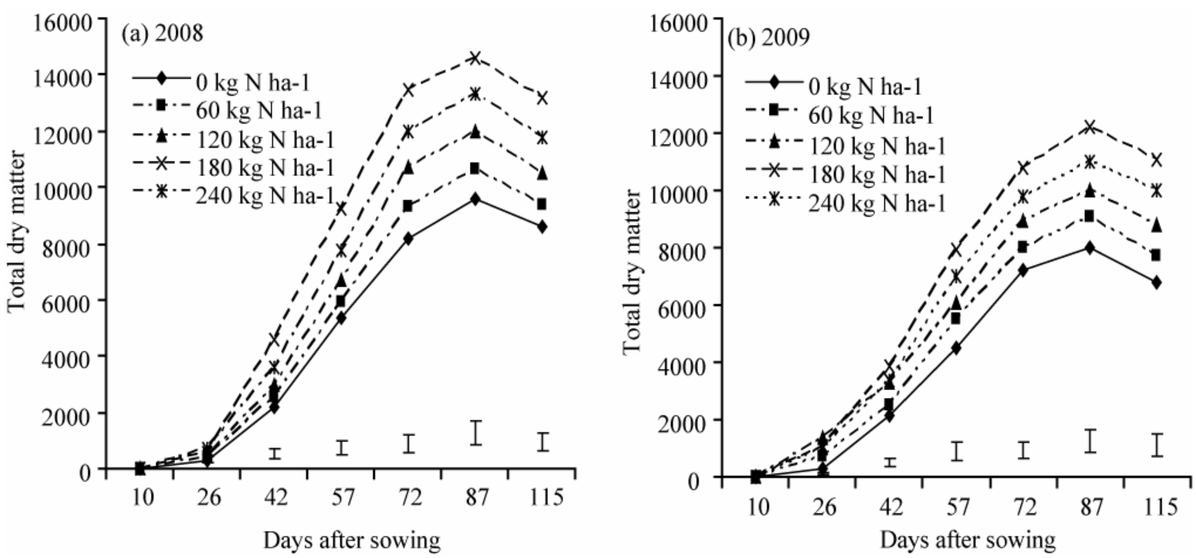

Fig. 5. Changes in total dry matter (kg ha^{-1}) during the crop cycle as affected by different nitrogen levels during 2008 (a) & 2009 (b); Bars represent standard error of mean.

Crop growth rate: Fig. 6 & 7 demonstrate the effect of treatments on mean crop growth rate (CGR) during the season. Year effect was significant; mean maximum CGR (15.0 vs 14.3 g $m^{-2}d^{-1}$) was observed during 2008 and 2009, respectively. Hysun-38 gave maximum (19.6 g $m^{-2}d^{-1}$) CGR followed by Pioneer-64A93 (18.0 g $m^{-2}d^{-1}$) and minimum (17.1 g $m^{-2}d^{-1}$) value of CGR was observed in Hysun-33 sunflower hybrid (Fig. 6). Application of different rates of nitrogen fertilizers also resulted in significant on CGR throughout the growth. Maximum (19.5 g $m^{-2}d^{-1}$) CGR was observed in N_4 (180 kg N ha^{-1}) treatment that was statistically at par with N_5 (240 kg N ha^{-1}) treatment (18.6 $gm^{-2}d^{-1}$) and minimum (15.6 g $m^{-2}d^{-1}$) CGR was observed by N_1 (0 kg N ha^{-1}) treatment, respectively (Fig. 7). Difference in CGR between N_2 (60 kg N ha^{-1}) and N_3 (120 kg N ha^{-1}) were also significant throughout.

Net assimilation rate: Net assimilation rate (NAR) was influenced significantly by hybrids and nitrogen levels. The year effect was significant; mean NAR was higher (6.69 vs 6.32 g $m^{-2}d^{-1}$) in 2008 and minimum (5.98 vs 5.80 g $m^{-2}d^{-1}$) NAR was observed during 2009 (Fig. 8). Additionally, Hysun-38 gave higher (6.96 g $m^{-2}d^{-1}$) values of NAR, followed by Pioneer-64A93 (6.42 $gm^{-2}d^{-1}$) and statistically minimum (6.13 g $m^{-2}d^{-1}$) value of NAR was recorded in Hysun-33. Effect of different nitrogen levels on NAR was significant and cubic in nature with increasing trend of nitrogen fertilizer (Fig. 9). Maximum (6.85 g $m^{-2}d^{-1}$) NAR was observed in N_4 (180 kg N ha^{-1}) treatment which was statistically at par with N_5 (240 kg N ha^{-1}) treatment (6.73 g $m^{-2}d^{-1}$) and minimum (4.15 g $m^{-2}d^{-1}$) NAR was obtained by N_1 (0 kg N ha^{-1}).

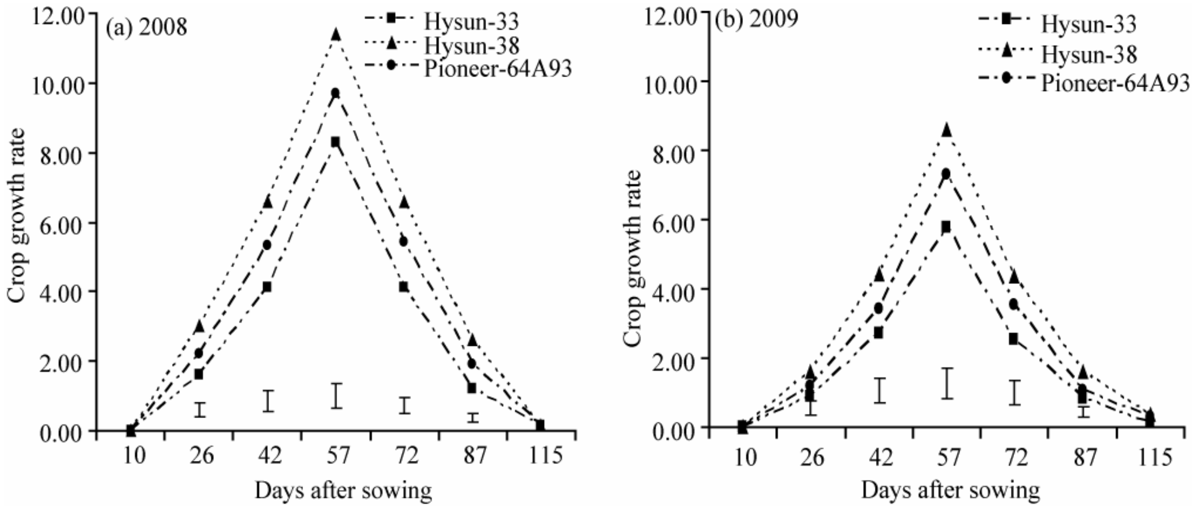

Fig. 6. Changes in crop growth rate (g m^{-2} d^{-1}) during the crop cycle as affected by different sunflower hybrids during 2008 (a) & 2009 (b); Bars represent standard error of mean.

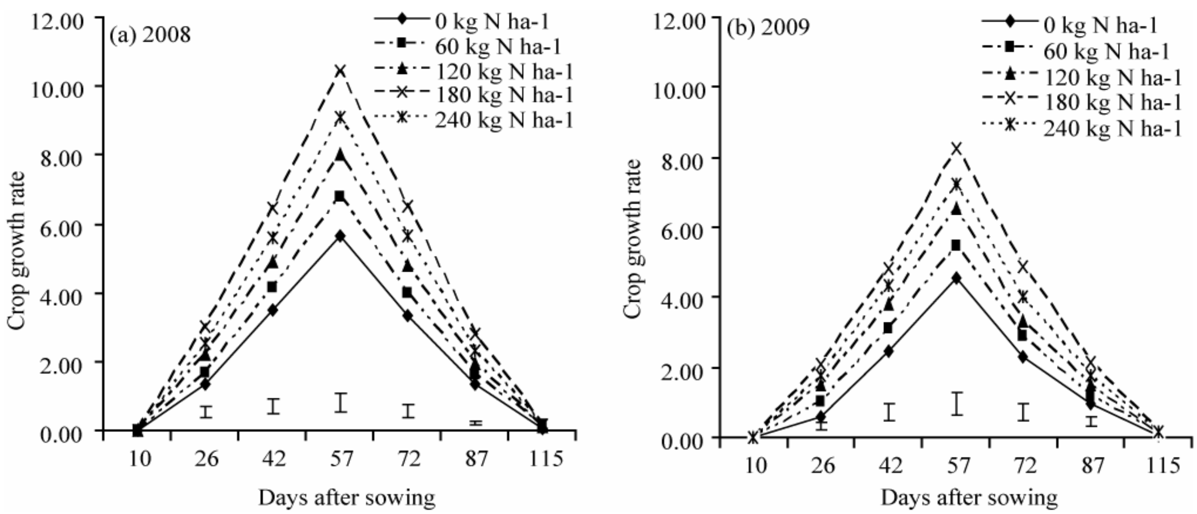

Fig. 7. Changes in crop growth rate (g m^{-2} d^{-1}) during the crop cycle as affected by different nitrogen levels during (a) 2008 (a) & 2009 (b); Bars represent standard error of mean.

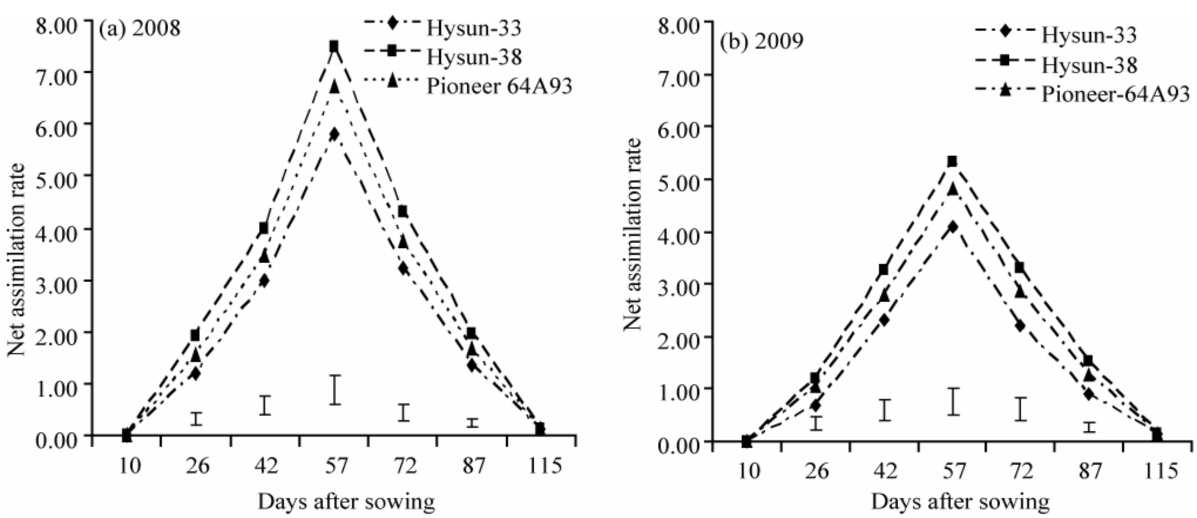

Fig. 8. Changes in net assimilation rate (g m^{-2} d^{-1}) during the crop cycle as affected by different hybrids during 2008 (a) and 2009 (b); Bars represent standard error of mean.

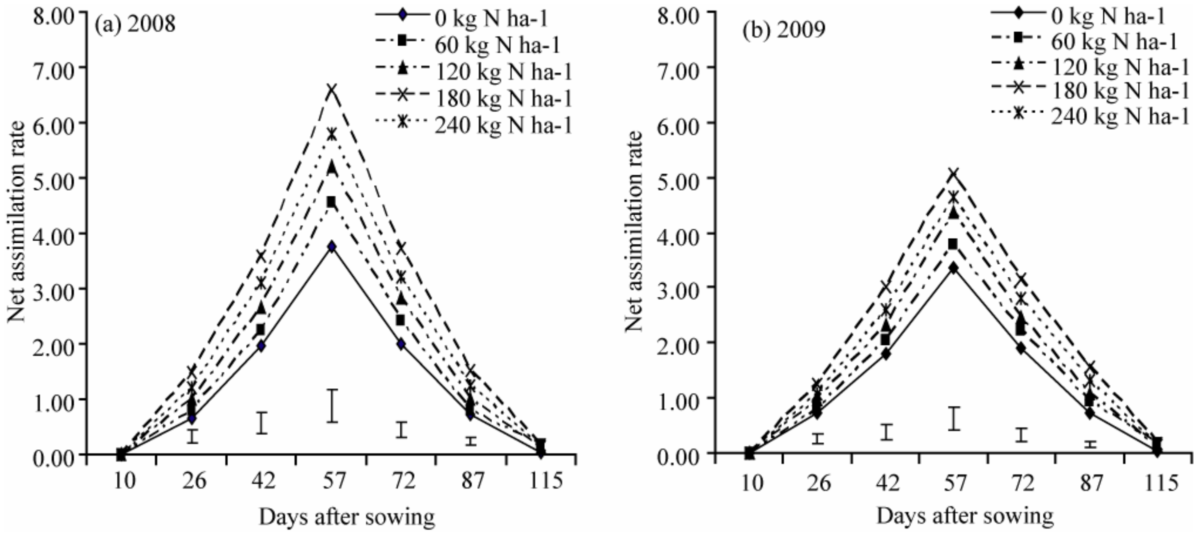

Fig. 9. Changes in net assimilation rate (g m^{-2} d^{-1}) during the crop cycle as affected by different nitrogen levels in 2008 (a) & 2009 (b); Bars represent standard error of mean.

Yield and yield components

Head diameter: All the sunflower hybrids showed significant positive effect for head diameter. This is because of the fact that breeder's always select medium size heads as these usually produce medium size achenes that contain more oil as compared to large size achenes (Anwar-ul-Haq *et al.,* 2006). The plants have more (18.1 cm) head diameter during 2008 than in 2009 (16.7 cm), respectively. In general, Hysun-38 gave maximum (18.2 cm) head diameter followed by Hysun-33 (17.1 cm) and minimum (16.9 cm) head diameter was observed by Pioneer-64A93. Furthermore, response of nitrogen fertilizer with different N levels on head diameter was highest with increasing nitrogen fertilizer. N_4 treatment (180 kg N ha^{-1}) produced maximum (19.9 cm) head diameter that was statistically at par with N_5 (240 kg N ha^{-1}) treatment (19.0 cm) head diameter and minimum (14.4 cm) head diameter was recorded in N_1 (0 kg N ha^{-1}). These results confirm the findings of Iqbal & Ashraf (2006); Munir *et al.,* (2007).

Number of grains per head: Results showed that increasing the rates of N have positive effects on number of achenes per head. Achenes per head is the most important yield component that a breeder should consider when selecting for higher yields under non-stress conditions as well as for the contribution of oil content by that sunflower hybrids (Miralles *et al.,* 1997). Hysun-38 showed significantly higher (941) achenes per head followed by Pioneer-64A93 (926) and minimum (908) values of achenes per head were recorded by Hysun-33, respectively. As for as different N rates are concerned, N_4 (180 kg N ha^{-1}) treatment produced statistically higher (1055) achenes per head which was statistically at par (1036) with N_5 (240 kg N ha^{-1}), while statistically minimum (737) value of achenes per head was observed in N_1 (0 kg N ha^{-1}) as demonstrated in Table 1. The interaction between sunflower hybrids and different levels of nitrogen treatments was significant with respect to achenes per head (Table 3). Treatments combination Hysun-38 x N_4 (180 kg N ha^{-1}) gave maximum number of achenes per head. However, it was statistically at par with the hybrids during 2009.

Table 1. Effect of different nitrogen rates on achene yield and its components of sunflower hybrids.

Treatments/year	Head diameter (cm)		Number of achenes ($head^{-1}$)		1000 achene weight (g)	
	2008	2009	2008	2009	2008	2009
Hysun-33	17.4 b	16.8 ab	928 c	888 c	42 c	38 c
Hysun-38	19.4 a	17.1 a	957 a	926 a	46 a	44 a
Pioneer-64A93	17.5 b	16.3 b	945 b	908 b	43 b	40 b
LSD (5 %)	0.32	0.51	4.12	7.61	0.43	0.42
	Nitrogen (kg ha^{-1})					
0	15.2 d	13.5 e	751 d	724 e	34 e	32 e
60	17.8 c	15.2 d	873 c	830 d	38 d	36 d
120	18.6 b	16.9 c	1002 b	896 c	45 c	41 c
180	19.5 a	20.2 a	1044 a	1066 a	51 a	47 a
240	19.8 a	18.2 b	1049 a	1023 b	49 b	46 b
LSD (5 %)	0.58	1.12	19.30	23.59	0.97	0.95
Interaction (H x N)	NS	NS	*	*	NS	NS
Year effect	*	NS	*	NS	*	NS

Figures in the same column with different letters differ significantly at 5 % level of probability. *, ** significant at 5 % and 1 %, respectively. NS - non significant

Table 2. Effect of nitrogen levels on different yield parameters of sunflower hybrids under agro-climatic conditions Faisalabad-Pakistan.

Treatments/year	Achene yield (kg ha^{-1})		Harvest Index (%)		Achene oil content (%)	
	2008	2009	2008	2009	2008	2009
Hysun-33	2969 c	2868 c	23.8	23.6	40.9 b	39.8 b
Hysun-38	3118 a	3052 a	22.8	24.7	42.4 a	40.9 a
Pioneer-64A93	3009 b	2956 b	24.1	24.5	40.2 c	40.1 b
LSD (5 %)	12.2	14.7	3.9	2.4	0.19	0.39
	Nitrogen (kg ha^{-1})					
0	2232 e	2185 e	20.2 d	20.1 d	43.5 a	42.4 a
60	2859 d	2780 d	22.8 c	22.7 c	42.5 b	41.3 b
120	3028 c	2968 c	23.7 b	23.8 b	40.2 c	40.2 c
180	3587 a	3552 a	25.5 a	25.4 a	39.7 d	38.8 d
240	3446 b	3292 b	25.2 b	24.7 ab	38.6 e	37.7 e
LSD (5 %)	39.5	25.2	0.9	1.1	0.63	0.78
Interaction (H x N)	**	**	NS	NS	**	**
Year effect	*	NS	*	NS	*	NS

Figures in the same column with different letters differ significantly at 5 % level of probability. *, ** significant at 5 % and 1 %, respectively. NS - non significant

Table 3. Interaction between hybrids and different nitrogen rates on achene yield and oil content of sunflower under agro-climatic conditions Faisalabad-Pakistan.

Treatments/nitrogen (kg ha^{-1})	Number of achenes (head^{-1})					
	2008			2009		
	Hysun-33	Hysun-38	Pioneer-64A93	Hysun-33	Hysun-38	Pioneer-64A93
0	576 j	588 i	570 j	564 ef	525 f	559 f
60	724 g	808 e	702 h	702 cde	730 bcd	653 def
120	811 e	856 d	801 f	788 abcd	849 ab	702 cd
180	901 b	904 a	901 b	810 abc	896 a	868 a
240	871 c	901 b	863 c	879 a	879 a	801 abc
LSD (5 %)		**2.9**			**38.2**	
	Achene yield (kg ha^{-1})					
0	2149 g	2257 g	2258 g	2103 f	2218 f	2201 f
60	2775 f	2928 def	2842 ef	2740 e	2836 de	2793 e
120	2950 def	3105 d	3003 de	2848 de	3068 bcd	2955 cde
180	3502 ab	3657 a	3571 ab	3491 a	3571 a	3560 a
240	3410 bc	3589 ab	3307 c	3105 bc	3509 a	3235 b
LSD (5 %)		**169.8**			**221.7**	
	Oil content (%)					
0	43.1 bcde	44.2 ab	41.2bcdef	42.2 b	43.2 a	40.3 b
60	42.4 abc	44.9 a	43.2 abc	40.6 d	41.7 bc	41.2 cd
120	40.3cdefg	40.3cdefg	37.3 g	39.2 e	39.2 ef	39.4 c
180	38.6 efg	42.2 abcd	39.3 defg	38.0 gh	41.0 cd	38.7 efg
240	38.2 g	39.1 efg	38.4 fg	37.1 i	38.2 fgh	37.5 hi
LSD (5 %)		**2.86**			**0.83**	

1000 achene weight: In case of thousand achenes weight (g), Hysun-38 gave maximum (45.0 g) 1000 achene weight, followed by Hysun-33 (40.0 g) and minimum 1000-achene weight (40.0 g) was observed in Pioneer-64A93 sunflower hybrid. Maximum (49.0 g) 1000 achene weight was produced in N_4 (180 kg N ha^{-1}) treatment which was statistically at par (48.0 g) with N_5 (240 kg N ha^{-1}) treatment, while minimum (33.0 g) 1000-achene weight was obtained by the treatment without application of nitrogen fertilizer (Table 1).

Achene yield: The effect of treatments on achene yield was highly significant (3029 vs. 2958 kg ha^{-1}) during 2008 and 2009, respectively (Table 2). Maximum achene yield was recorded from Hysun-38 (3083 kg ha^{-1}) followed by Pioneer-64A93 (2984 kg ha^{-1}) and minimum (2917 kg ha^{-1}) achene yield was observed in Hysun-33. N_4 (180 kg N ha^{-1}) treatment produced maximum achene yield (3569 kg ha^{-1}) which was statistically at par (3369 kg ha^{-1}) with N_5 (240 kg ha^{-1}) treatment. Minimum (2209 kg ha^{-1}) achene yield was observed by the treatment where there was no application of nitrogen fertilizer (Table 2). Interaction between sunflower hybrids and different levels of N treatments was significant regarding achene yield (Table 3). In both years, Hysun-38 x N_4 (180 kg N ha^{-1}) treatment combination gave maximum achene yield. However, this was statistically at par with all other hybrid combinations.

Harvest index: The HI represents the physiological competence of plants to change the fraction of photo-assimilates to grain yield. However, sunflower crop had an average HI (23.4 vs 23.2%) during the year 2008 and 2009, respectively. The sunflower hybrid differences with respect to HI were significant, maximum (24.3%) HI was observed by Pioneer-64A93 followed by Hysun-33 (23.6%) as compared to Hysun-38 (22.8%) at final harvest. Similarly, N_4 (180 kg N ha^{-1}) treatment gave maximum HI compared with all other N rates (Table 2).

Oil content: Table 2 showed that Hysun-38 produced maximum (41.9%) oil content (GOC) followed by Hysun-33 (40.4%) and Pioneer-64A93 (40.1%) sunflower hybrid. Furthermore, response of nitrogen fertilizer rates was decreasing with increasing application of nitrogen fertilizer (Anastasi *et al.,* 2000; Kirimiti *et al.,* 2001). Maximum GOC (42.8%) were produced in N_1 treatment (0 kg N ha^{-1}) which was statistically at par (41.9%) with N_2 (60 kg N ha^{-1}) treatment. The standard treatment N_3 (120 kg N ha^{-1}) produced GOC at 40.2% that was significantly higher (39.3%) value of GOC by N_4 (180 kg N ha^{-1}) treatment. The minimum GOC (38.4%) observed by the treatment where there was maximum application of nitrogen fertilizer (240 kg N ha^{-1}). The interaction between sunflower hybrids and different levels of nitrogen treatments were highly significant regarding oil content (Table 3).

Discussion

The nitrogen utilization had strong effect on the improvement and development of leaf area in terms of radiation interception and thus crop growth rate (CGR) of sunflower hybrids at different stages during crop cycle. The values of CGR were greatly dependent on many factors including genotype and environment (Miralles *et al.,* 1997; Gholinezhad *et al.,* 2009; Nasim *et al.,* 2011; Nasim *et al.,* 2012), so, application of nitrogen have the positive effects on CGR (rate of DM accumulation) in sunflower crop (Fig. 2). Plants which received more nitrogen had larger leaf area index (LAI) compared with plants with low nitrogen consumption (Connor & Sadras 1992; Cheema *et al.,* 2001). The enhancement in the NAR was accredited due to maximum vegetative growth as explained by Abelardo & Hall (2002); that was higher as in response with the application of nitrogen fertilizer. Results showed that effect of different nitrogen levels on LAI was significant (Fig. 2 and 3). The superior leaf development in sunflower hybrids was endorsed because of cell division and cell enlargement (Andrade, 1995). As N application rate was increased, maximum LAI was observed in the treatment 240 kg ha^{-1} while minimum leaf area index was observed by the treatment in which there was no application of N fertilizer because plant photosynthesis rate increased with nitrogen consumption and vice versa. The results of this study about the effect of applying different amounts of nitrogen on leaf area agree well with Ortis *et al.,* (2005). Nitrogen utilization had significant effect on biological yield. The shortage of N decreases leaf size which in turn is the cause of lower amount of light absorption and light use efficiency for plant photosynthesis that leads to decrease total dry matter or biological yield and vice versa (Fig. 5). The improvement in TDM with increasing nitrogen rates were due to better CGR (Dordas & Siolas 2009), which gave higher photosynthates, LAI and ultimately produced higher biological yield. Similar results were reported by Dreccer *et al.,* (2000). The deficiency of N affects the improvement and growth of source and sink, as well as the number of achenes per head (Mantese *et al.,* 2006; Cantagallo *et al.,* 2009). Number of grains $head^{-1}$ increased with nitrogen utilization efficiency because of improvement of CGR as well as net assimilation rate which shows that increasing nitrogen consumption caused higher light utilization efficiency especially at all growth stage of crop (Uhart & Andrade, 1995). Furthermore, there is a close relationship between crop growth rate and N by increasing leaf area and photosynthesis as reported by others (Angadi & Entz, 2002; Vega & Hall, 2002).

Increasing the use of N fertilizer also has the significant effect on 1000-achene weight (Table 1). Achene weight can be expected from the quantity of dry matter obtained to be transported to head from the flowering parts to achenes. So, this is function of the durability of leaf area after flowering stage as well as the sink-source relationship as explained by Gardner *et al.,* (1994). Additionally, it can be explained that stem is important as a little storage source of portable non building carbohydrates, which also transport them to achene after flowering as well physiological maturity. The acheme weight is an important yield contributing factor, which is an important trait showing the potential of hybrid (Anwar-ul-Haq *et al.,* 2006). This ability of the plant is due to access for more nitrogen and increasing reproductive and productive parts as well as increasing nitrogen consumption head diameter and 1000-achene weight increased due to more access to absorbing nutrients. The utilization of higher amount of N fertilizer at optimum irrigation as well as all essential ideal growing conditions required for the crop to flourish, cause considerable increase in achene yield, so due to increasing nitrogen fertilizer, it increased the achene yield but reduced GOC (Zubillaga *et al.,* 2002; Wajid *et al.,* 2010; Zahoor *et al.,* 2010) and among different yield parameters (number of achenes per head, achene yield and achene oil content), sunflower hybrids and different nitrogen levels are significant among each other (Table 2). Wajid *et al.,* (2010); Abbadi Gerendas (2009) verify results that nitrogen use efficiency increase crop growth, leaf area index, leaf area duration, head diameter, 1000-achene weight and ultimately considerable increase in achene yield (Table 1, Table 2). This might be due to genetic potential of sunflower hybrids as clarified by Ozer *et al.,* (2004); Sadras *et al*., (2009). Vega & Hall (2002) reported that there were increase in achene yield of sunflower hybrids in response to N fertilization and with less or no application of N fertilizer there will be low achene yield. The difference between maximum and minimum of Harvest Index (HI) obtained at different nitrogen levels was statistically significant (Table 2). The finding from this study showed that nitrogen application did not change the way at which photosynthesis distributed and increased the achene yield with the same level as dry matter (Gholinezhad *et al.,* 2009). Significantly high HI for Pioneer-64A93 might be achieved due to its genotypic dominance to utilize more photo assimilates for achene yield (Koutroubas *et al.*, 2008; Sinclair 1998; Jin *et al.*, 2010). Harvest index involves the comparative distribution of photosynthesis products between economical sinks. The difference between maximum and minimum of harvest index obtained at different nitrogen levels was statistically significant (Table 2). Moreover, nitrogen application did not change the way at which photosynthesis partitioning and increased the achene. There are many studies in which it is clue that application of various N levels does not have any effect on harvest index as reported by Singh *et al.*, (1996). All the yield and yield components such as head diameter, number of achene per head, 1000-achene weight, biological yield harvest index etc., are influenced by application of N because of major nutrient and ultimately increase the yield of the crop.

Conclusions

On the basis of findings, following conclusions can be made that includes; increasing nitrogen fertilizer from 0 to 240 kg N ha^{-1} all the above mentioned yield and yield components increased significantly. However the highest value of 1000-achene weight obtained from nitrogen treatment of 240 kg N ha^{-1}. From this study, it can be accomplished that Hysun-38 should be planted to achieve higher achene yield as well as oil contents under agro-climatic conditions of Faisalabad-Pakistan. Among different nitrogen levels, 180 kg ha^{-1} is superior under well irrigated conditions to obtained maximum economic benefits and maximum yield can be achieved under best management practices.

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