www.biodicon.com Biological Diversity and Conservation

SSN 1308-8084 Online; ISSN 1308-5301 Print 3/3 (2010) 121-125

# Nitrogen use efficiency, yield and other characteristics of sunflower (*Helianthus annuus* L.) hybrids as affected by different levels of nitrogen

Abdul **QAHAR**[1], Zafar Hayat KHAN [1], Sajjad ANWAR [2], Hayat BADSHAH [3] , Hidayat ULLAH [4*]

[1] Department of Agronomy, Khyber Pakhtunkhwa Agricultural University, Peshawar, Pakistan
[2] Sugar Cane Research Institute, Mardan, Pakistan
[3] Agricultural Research Institute, Tarnab, Peshawar, Pakistan
[4] Department of Plant Breeding and Genetics, Khyber Pakhtunkhwa Agricultural University, Peshawar, Pakistan

**Abstract**

To assess the nitrogen use efficiency of hybrid sunflower (*Helianthus annuus L.*), an experiment was conducted at New Developmental Farm, Khyber Pakhtunkhwa, Agricultural University Peshawar-Pakistan. Randomized complete block (RCB) design with split plot arrangement, replicated four times, was used. Sunflower hybrids (Suncross, Gulshan-98, Aritar-93, and Peshawar-93) were allotted to main plots while nitrogen levels (0, 45, 90, 135, 180, and 225 kg $ha^{-1}$) to the sub-plots. Statistical analysis of the data revealed that nitrogen had significant effects ($P \leq 0.05$) on all parameters under study. Days to button formation and flowering decreased with increase in nitrogen levels. The delayed button formation (35.63) and flowering (52.06) were observed in controlled plots, while earlier button formation (31.94) and flowering (48.56) were noted when 225 kg N $ha^{-1}$ was applied to the crop. Among hybrids Peshawar-93 took less days (45.29), while Gulshan-98 took more days (56.42) to flowering. Maximum plant height (87.54 cm), seed yield $ha^{-1}$ (1302.75 kg) and leaf area $plant^{-1}$ (9909.5 $cm^2$) was recorded in plots with highest dose of nitrogen (225 kg $ha^{-1}$). Maximum leaf area $plant^{-1}$ (8777.53 $cm^2$) has produced by Suncross. Values of nitrogen use efficiency were higher in controlled plots (342) and lower (5.83) in plots with highest dose of nitrogen (225 kg $ha^{-1}$). Out of tested hybrids, Suncross produced maximum yield with maximum dose of nitrogen. It is therefore suggested that Suncross should be sown in Peshawar Valley by farmers with N application at the rate of 225 kg $ha^{-1}$.

**Key words:** *Helianthus annus*, Hybrids, Nitrogen Efficacy, Levels of nitrogen

## 1. Introduction

Sunflower (*Helianthus annuus* L.) is a member of the family *Compositae*. It is said to be of American origin (Heiser, 1976). Sunflower is a valuable plant both from economic and ornamental point of view. It is believed that it has been evolved from sub-species as a mutation with less extensive branching than that exhibited by the wild form (Heiser, 1976). The cultivated sunflower is a tall, erect and unbranched, coarse annual, with a distinctive large golden head (Arnon and Aslam, 1991).

Sunflower is considered to be a good source of both oil and proteins. Oil content of sunflower ranges from 39-49%. Sunflower oil is generally considered a premium oil because of its light color, high level of unsaturated fatty acids and lack of linolenic acid, bland flavor and high smoke points. The primary fatty acids in the oil are oleic and linoleic (typically 90% unsaturated fatty acids), with the remainder consisting of palmitic and stearic saturated fatty acids. Due to its edible oil content it is very important food supplement. Protein percentage of sunflower meal ranges from 28% for non-dehulled seeds to 42% for completely dehulled seeds (Putnam *et al*., 1990). Sunflower is considered to be the most suitable for margarine production, for hydrogenation and as cooking oil. The industrial uses of sunflower are the production of soaps, paints, varnishes and candles. The resulting meal is a rich source of protein utilized in the livestock and poultry feeds after oil extraction.

* *Corresponding author* / Haberleşmeden sorumlu yazar: Tel.: +923339196096; E-mail: shabkadar@yahoo.com

 

Pakistan has been facing acute shortage of edible oil. A huge amount of foreign exchange (59093.4 Million Rupees) was spent during year 2006-07 on the import of oil (Anonymous, 2008). This huge burden of foreign exchange reserve necessitates the urgency of increasing domestic production of oil seed crops without disturbing the present cropping pattern.

In Pakistan, total area under sunflower cultivation during 2009 was 0.3197 million hectares with total production of 0.42 million tones. In Khyber Pakhtunkhwa province, total area under sunflower cultivation was 527 hectares with production of 812 tones (MINFAL, 2010).

Fertilizer is one of the most effective tools of increasing crop yields. Our farmers are mostly illiterate and can not precisely follow scientific and agricultural instructions necessary for maximum output in term of yield. Successful crop husbandry is a complex combination and interaction of different agricultural inputs in varying amounts, which mainly depends on the nature of the crop, soil structure/texture and environmental conditions.

Sunflower plant needs sufficient quantities of plant food nutrients depending upon soil fertility to produce a bumper crop. Our soils have been exhausted due to mono crop cultivation without giving proper attention to replenish the plant food nutrients in it. The aim of this study was to evaluate optimum nitrogen rate and select high yielding sunflower hybrid for cultivation in Peshawar Valley. This experiment was designed in the year 2000 to study phenology, yield and nitrogen use efficiency of different sunflower hybrids, when grown under different levels of nitrogen.

## 2. Materials and methods

Four hybrids (Suncross, Gulshan-98, Aritar-93, and Peshawar-93) were plated with six nitrogen rates (0, 45, 90, 135, 180, and 225 kg $ha^{-1}$). The hybrids under study were Suncross, Gulshan-98, Aritar-93 and Peshawar-93. Suncross is an imported Australian hybrid, while the other three have been evolved from the inbred lines of TMS-7 x TRL-14 (Gulshan-98), TMS-17 x TRL-13 (Aritar-93) and TMS-11 x TRL-7 (Peshawar-93) respectively. The experiment was laid out in randomized complete block (RCB) design with split plot arrangement replicated four times. Hybrids were allotted to main plots and nitrogen levels to subplots. Data were recorded on the following parameters:

*2.1.1. Days to button formation*

Days to button formation were calculated when 80% plants reached to button stage (flowers in bud). Days were counted from date of sowing to the date of button formation.

*2.1.2. Days to 50% flowering*

Dates were recorded for 50% flowering emergence in each treatment and number of days were counted from date of sowing.

*2.1.3. Plant height (cm)*

Ten plants from four central rows were randomly selected. Plant height was measured from ground level to the top edge of the collar disk with the help of measuring tape.

*2.1.4. Leaf area plant$^{-1}$($cm^2$)*

First a constant factor for leaf area was calculated by measuring the length and width of the representative large, medium and small size leaves from ten randomly selected plants from each subplot. Leaf area of the selected plant leaves was measured with the help of graph paper by counting small and big squares. Then this leaf area was divided by their average leaf length and leaf width. A different factor for each hybrid was observed which are 0.9, 0.7, 0.9, and 0.6 for Suncross, Gulshan-98, Peshawar-93 and Aritar-93 respectively.

*2.1.5. Seed yield ha$^{-1}$(kg)*

Seed yield per hectare was calculated by multiplying seed yield per disc with plant population per hectare at harvest.

*2.1.6. Nitrogen use efficiency*

Nitrogen use efficiency (NUE) was calculated using the formula suggested by Moll *et al.*, (1982) by dividing seed yield (Gw) by nitrogen (N) applied to the soil plus mineral nitrogen in soil before sowing (Ns).

**{NUE = Gw / N + Ns}**

The data recorded were statistically analyzed using analysis of variance technique (ANOVA) appropriate for randomized complete block design with split plot arrangement. Regression/trend analysis was carried out when F-values were significant. The following model was used to analyze the data (Gomez and Gomez, 1984).

$$\{Yijk = \mu + \rho i + \alpha j + \gamma ij + \beta k + (\alpha\beta) jk + \varepsilon ijk\}$$

Where

$Yijk$ = Yield, $\mu$ = General mean, $\rho i$ = $i^{th}$ replication, $\alpha j$ = $j^{th}$ Hybrids

$\gamma ij$ = Main plot error, $\beta k$ = $k^{th}$ Nitrogen levels,

$(\alpha\beta) jk$ = Interaction between hybrid and nitrogen level

$\varepsilon ijk$ = Sub plot error

## 3. Results and discussion

### *3.1. Days to button formation*

Statistical analysis of the data revealed that nitrogen levels had significant effect (P≤0.05) on days to button formation, while hybrids (H) and hybrid ×nitrogen levels (H×N) interactions had no significant effect on days to button formation (Table 1). Days to button formation decreased with increase in N application. Mean values for nitrogen levels showed that maximum number of days to button formation (35.6) was observed in controlled plots, while minimum number of days to button formation (31.94) was observed in plots with nitrogen level of 225 kg $ha^{-1}$. Similar results were reported by Loubser and Human (1993), who concluded that high nitrogen level decreased days to button formation.

Table 1. Means for days to button formation of sunflower hybrids affected by N levels

| **Nitrogen level (Kg $ha^{-1}$)** | **Hybrids** | | | | **Means** |
|---|---|---|---|---|---|
| | **Suncross** | **Gulshan-98** | **Aritar-93** | **Peshawar-93** | |
| 0 | 36.75 | 36.00 | 36.00 | 33.75 | 35.63 a |
| 45 | 34.00 | 34.25 | 35.75 | 32.50 | 34.13 b |
| 90 | 34.00 | 33.00 | 34.75 | 35.75 | 34.38 ab |
| 135 | 34.25 | 34.00 | 33.50 | 32.00 | 33.44 bc |
| 180 | 32.00 | 34.00 | 31.25 | 31.25 | 32.13 cd |
| 225 | 32.50 | 32.00 | 32.00 | 31.25 | 31.94 d |
| **Means** | 33.92 | 33.88 | 33.88 | 32.75 | -------- |

LSD for N levels at P<0.05 = 1.44

### *3.2. Days to 50% flowering*

Statistical analysis of the data revealed that hybrids and different levels of nitrogen had significant effect (P≤0.05) on days to 50% flowering (Table 2). The main effect of hybrid indicated that maximum number of days to flowering (56.42) was taken by Gulshan-98, whereas minimum number of days (45.29) was taken by Peshawar-93. Maximum number of days to flowering (53.19) was recorded in plots with nitrogen level of 135 kg $ha^{-1}$which was not significantly different from days taken by plots with 0 and 45 kg N $ha^{-1}$. The (H×N) interaction had no significant effect on days to flowering. These results are not in conformity with Ali (1998), who reported that days to 50% flowering increased with increase in nitrogen level. He reported that maximum days to flowering were observed in plots with nitrogen applied at the rate of 135 kg $ha^{-1}$, while minimum days to flowering were taken by plants received nitrogen at the rate of 120 kg $ha^{-1}$.

Table 2. Means for days to flowering of sunflower hybrids as affected by N levels

| **Nitrogen level (Kg $ha^{-1}$)** | **Hybrids** | | | | **Means** |
|---|---|---|---|---|---|
| | **Suncross** | **Gulshan-98** | **Aritar-93** | **Peshawar-93** | |
| 0 | 56.25 | 55.75 | 50.25 | 46.00 | 52.06 a |
| 45 | 53.50 | 60.25 | 52.00 | 43.50 | 52.31 a |
| 90 | 52.00 | 59.25 | 50.75 | 44.75 | 51.69 ab |
| 135 | 55.00 | 56.50 | 53.00 | 48.25 | 53.19 a |
| 180 | 47.75 | 54.00 | 49.75 | 45.00 | 49.13 bc |
| 225 | 46.25 | 52.75 | 51.00 | 44.25 | 48.56 c |
| **Means** | 51.79 b | 56.42 a | 51.13 b | 45.29 c | -------- |

LSD for N levels at P<0.05 = 2.77
LSD for Hybrids at P<0.05 = 4.26

### *3.3. Plant height*

Different levels of nitrogen significantly affected (P≤0.05) plant height, while hybrid and their interaction had non-significant effect on plant height (Table 3). Mean values for the nitrogen level showed that maximum plant height (87.54) was observed in plots with nitrogen at the rate of 225kg $ha^{-1}$. The data revealed that plant height increased with increase in nitrogen level. Similar results were also reported by Nur (1975), who states that increase in nitrogen level usually increase plant height. These results are however not supported by Ali (1998), who reported significant effect of hybrid on plant height.

Table 3. Means for plant height (cm) of sunflower hybrids as affected by N levels

| Nitrogen level (Kg ha$^{-1}$) | Hybrids | | | | Means |
|---|---|---|---|---|---|
| | Suncross | Gulshan-98 | Aritar-93 | Peshawar-93 | |
| 0 | 74.98 | 72.53 | 65.6 | 76.65 | 72.44 c |
| 45 | 78.98 | 77.28 | 71.73 | 82.2 | 77.55 b |
| 90 | 81.93 | 75.6 | 75.58 | 82.05 | 78.79 b |
| 135 | 84.95 | 81.6 | 76.48 | 78.1 | 80.29 b |
| 180 | 89.48 | 84.73 | 81.63 | 82.75 | 84.65 a |
| 225 | 84.75 | 90.35 | 83.55 | 91.5 | 87.54 a |
| **Means** | 82.51 | 80.35 | 75.77 | 82.21 | -------- |

LSD for N levels at P<0.05 = 3.03

*3.4. Leaf area plant$^{-1}$*

Data regarding leaf area presented in Table 4. Different levels of nitrogen, hybrids and their interaction significantly affected leaf area plant$^{-1}$ at (P≤0.05). Suncross recorded maximum leaf area plant$^{-1}$(12019 cm$^2$) at maximum nitrogen level of 225kg ha$^{-1}$. Illeiv and Vangelova (1977) reported that leaf area increased by 2.8, 22.23, and 36 % respectively with increase in nitrogen level. Effects of N on leaf size are largely due to effects on cell production in the un-emerged leaf and on both cell production and expansion during the first phase of expansion of the emerged leaf (Trapani *et al.* 1999). Hybrids resulted in significantly different leaf area. Similar results are reported by Ali (1998) stating sunflower hybrids have significant effect on leaf area.

Table 4. Means for leaf area plant$^{-1}$ (cm$^2$) of sunflower hybrids as affected by N levels

| Nitrogen level (Kg ha$^{-1}$) | Hybrids | | | | Means |
|---|---|---|---|---|---|
| | Suncross | Gulshan-98 | Aritar-93 | Peshawar-93 | |
| 0 | 6759 hi | 5242 lm | 3702 n | 5433 kl | 5284.00 f |
| 45 | 7046 ghi | 5657 kl | 3734 n | 6837 ghi | 5818.50 e |
| 90 | 7388 fgh | 6500 ij | 4735 m | 7450 fg | 6518.25 d |
| 135 | 8819 cd | 7057 ghi | 6068 jk | 8101 e | 7511.25 c |
| 180 | 10635 b | 8279 de | 6521 ij | 9174 c | 8652.25 b |
| 225 | 12019 a | 9287 c | 7732 ef | 10600 b | 9909.50 a |
| **Means** | 8777.67 a | 7003.67 b | 5415.33 c | 7932.50 a | -------- |

LSD for N levels at P<0.05 = 264.8
LSD for Hybrids at P<0.05 = 914.7
LSD for N×H at P<0.05 = 648.7

*3.5. Seed yield ha$^{-1}$*

As stated statistical analysis of the data also revealed that different levels of nitrogen had significant effects (P≤0.05) on seed yield ha$^{-1}$, while hybrids and (H×N) interaction had no significant effect on seed yield ha$^{-1}$ (Table 5). Mean values for N levels showed that maximum seed yield (1302.75 kg ha$^{-1}$) was recorded in plots applied with nitrogen at the rate of 225 kg ha$^{-1}$ while minimum seed yield(588.75 kg ha$^{-1}$) was obtained from plots with no nitrogen. Seed yield significantly increased with increase in nitrogen level. It might be due to proper application of nitrogen at proper time during the growth. Nitrogen usually increases vegetative growth of plants that ultimately increased leaf area, which is the key for photosynthesis. Maximum leaf area intercepted more sunlight and hence more seed formation resulting in more yield. These findings are in conformity with Morris (1975), Scheiner & Lavado (1999) and Ruffo *et al.* (2003) who reported that high doses of nitrogen increased seed yield. Similar results were also reported by Tianu *et al.* (1978), who concluded that seed yield was increased with increase in N rate.

Table 5. Means for seed yield (kg ha$^{-1}$) of sunflower hybrids as affected by N levels

| Nitrogen level (Kg ha$^{-1}$) | Hybrids | | | | Means |
|---|---|---|---|---|---|
| | Suncross | Gulshan-98 | Aritar-93 | Peshawar-93 | |
| 0 | 679 | 478 | 492 | 706 | 588.75 d |
| 45 | 842 | 587 | 533 | 934 | 724.00 c |
| 90 | 1106 | 593 | 703 | 921 | 830.75 c |
| 135 | 1367 | 994 | 1025 | 1128 | 1128.50 b |
| 180 | 1163 | 1141 | 896 | 1293 | 1123.25 b |
| 225 | 1545 | 1211 | 937 | 1518 | 1302.75 a |
| **Means** | 1117 | 834 | 764.33 | 1083.33 | -------- |

LSD for N levels at P<0.05 = 129.8

*3.6. Nitrogen use efficiency*

Significant (P≤0.05) effect of different levels of nitrogen use efficiency was observed, while hybrid and their interaction with nitrogen levels had non-significant effect (Table 6). Mean values for nitrogen use efficiency of the nitrogen levels indicated that maximum nitrogen use efficiency was recorded in controlled plots, while minimum nitrogen use efficiency was recorded in plots applied with nitrogen at the rate of 225 kg $ha^{-1}$. Nitrogen use efficiency significantly decreased with increase in nitrogen levels. These results are supported by Gutschick (1993) who reported increase in nitrogen use efficiency at optimum availability of nitrogen. He also stated that nitrogen use efficiency (NUE) increased as external nutrient concentration in soil decreased.

Table 6. Means for nitrogen use efficiency of sunflower hybrids affected by N levels

| **Nitrogen level (Kg $ha^{-1}$)** | **Hybrids** | | | | **Means** |
|---|---|---|---|---|---|
| | **Suncross** | **Gulshan-98** | **Aritar-93** | **Peshawar-93** | |
| 0 | 394.76 | 277.61 | 286.06 | 410.59 | 342.26 a |
| 45 | 18.02 | 12.55 | 11.39 | 20 | 15.49 b |
| 90 | 12.05 | 8.96 | 7.66 | 10.04 | 9.68 b |
| 135 | 9.99 | 7.27 | 7.49 | 8.25 | 8.25 b |
| 180 | 6.43 | 6.26 | 4.93 | 7.11 | 6.18 b |
| 225 | 7.15 | 5.34 | 4.13 | 6.69 | 5.83 b |
| **Means** | 74.73 | 52.99 | 53.61 | 77.11 | -------- |

LSD for N levels at P<0.05 = 25.27

## 4. Conclusions

It is clear from the results obtained in our study that Suncross hybrid can be cultivated in Peshawar with higher yields compared to other hybrids. Hybrids performed well when they were applied with 225 kg N $ha^{-1}$. Farmers in Peshawar Valley are therefore suggested to plant Suncross with applying 225 kg N $ha^{-1}$ to get maximum returns.

## References


Ali, M. 1998. Response of sunflower (*Helianthus annuus* L.) hybrids to various levels of nitrogen and phosphorus. M.Sc Thesis. Department of Agronomy, Khyber Pakhtunkhwa Agricultural University Peshawar, Pakistan. 23-58.

Anonymous. 2008. Vegetable oils imports. Pakistan Statistical Yearbook.

Arnon, A.S., and Aslam, S.M. 1991. Growth and yield responses of sunflower (*Helianthus annuus* L.) varieties as influenced by row spacing. Pakistan Journal of Science and Industrial Research. 34/8: 319-320.

Gomez, K.A., and A.A. Gomez. 1984. Statistical procedures for agricultural research. (2nd Ed.). John Wiley & Sons, NewYork. 247-254.

Gutschick, V.P. 1993. Nutrient-limited growth rates: roles of nutrient-use efficiency and of adaptations to increase uptake rate. Journal of Experimental Botany. 44/258: 41-51.

Heiser, C.B. 1976. The sunflower (*Helianthus annuus* L.). University Oklahoma Press, USA. pp. 198.

Illiev, V., and Vangelova, N. 1977. Effect of nitrogen on growth and photosynthetic productivity of sunflower (*Helianthus annuus* L.). Soil and Fertility 41/4: 4077-4080.

Loubser, H.L and Human, J.J. 1993. Effect of nitrogen and phosphorus fertilization on the phosphorus absorption by sunflowers (*Helianthus annuus* L.). Journal of Agriculture and Crop Science. 171/3: 206-215.

MINFAL, 2010. Agric. Statistics of Pakistan. Ministry of Food, Agric. and Livestock, Econ. Wing, Islamabad, Pakistan.65 - 112.

Moll, R.M., E.J. Kamprath, and Jakson, W.A. 1982. Analysis and interpretation which contribute to efficiency of nitrogen utilization. Agronomy Journal. 74:562-564.

Morris, A. 1975. Effect of nitrogen on sunflower (*Helianthus annuus* L.). Rhodesia Agricultural Journal. 72/6: 360.

Nur, I.M. 1975. Sunflower (*Helianthus annuus* L.) response to nitrogen fertilization at G.R.S. Acta Agronomica. 24: 463-466.

Putnam, D.H., E.S. Oplinger, D.R. Hicks, B.R. Durgan, D.M. Noetzel, R.A. Meronuck, J.D. Doll, and Schulte, E.E.1990. Sunflower (*Helianthus annuus* L.). Alternative Field Crops Manual. Agricultural Extension Service, University of Minnesota, St. Paul, MN.

Ruffo, M.L., F.O. Garcia, G.A. Bollero, K. Fabrizzi, and Ruiz, R.A. 2003. Nitrogen balance approach to sunflower (*Helianthus annuus* L.) fertilization. Communications in Soil Science and Plant Analysis. 34/17-18: 2645-2657.

Scheiner, J.D. and Lavado, R.S. 1999. Soil water content, absorption of nutrient elements, and responses to fertilization of sunflower (*Helianthus annuus* L.): a case study. Journal of Plant Nutrition. 22/2: 369-377.

Tianu, A., I. Pieu, P. Romoroga, S. Mate, M. Agnelescu, and Vasiliu, R. 1978. Effect of rate of nitrogen, distance between rows and sowing density on yield of principal crops in irrigated conditions. Abstracted in Field Crops Abstracts. 31/3: 2146.

Trapani, N, A.J. Hall, and Weber, M. 1999. Effects of constant and variable nitrogen supply on sunflower (*Helianthus annuus* L.) leaf cell number and size. Annals of Botany, London. 84/5: 599-606.


*(Received for publication 26 April 2010; The date of publication 01 December 2010)*