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Influence of nitrogen application on phenology, growth and yield of sunflower (*Helianthus annuus* L.)

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Abstract

Sunflower is one of the most important oil seed crop. Pakistan is facing a serious shortage of edible oil. Nitrogen plays an important role in improving the growth, yield and quality of all crops. So, an experiment was designed to evaluate the influence of different levels of nitrogen on phenology, growth and yield of Sunflower (*Helianthus annuus* L.). The study was carried out at Agronomic Research Area, College of Agriculture, Sargodha, during spring season, 2019. The experiment was laid out in Randomized Complete Block Design (RCBD having three replications. The treatments were comprised of different nitrogen levels (0, 55, 110, 165 and 220 kg ha^{-1}). Data regarding leaf area index (LAI), days taken to anthesis, days to maturity, plant height at maturity (cm), head diameter (cm), number of achenes per head, 1000-achenes weight (g), achene yield (kg ha^{-1}), total dry matter (kg ha^{-1}) and harvest index (%) of sunflower were taken by standard procedure. Results indicated that maximum leaf area index (4.68), days taken to anthesis (69.74), days to maturity (121.47), plant height at maturity (183.67 cm), head diameter (25.86 cm), number of achenes per head (2467), 1000-achenes weight (56 g), achene yield (3422 kg ha^{-1}), total dry matter (14046 kg ha^{-1}) and harvest index (24.38%) were recorded at 220 kg N ha^{-1}. So, it is recommended that application of nitrogen at the rate of 220 kg ha^{-1} is best for maximizing productivity of sunflower under agro-climatic conditions of Sargodha, Pakistan.

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Introduction

The Sunflower (*Helianthus annuus* L.) belongs to family Compositae. Its genus name is *Helianthus*. It is derived from Greek word *helios* "sun" and *Anthos* "flower". In Pakistan it is known as surajmukhi. It has the most significance position in the world as oilseed crop. It is widely spread and adoptable oil seed crop of world. It is 4th oil crop grown worldwide (Nasreen *et al*., 2015). In Pakistan, sunflower grown in both rain fed and irrigated area because it is drought tolerant crop. It shows positive response towards limitation of precipitation, irrigation and soil water to growth and yield (Unger, 1990). Its production has progressed due to innovations in genetics that resulted in improved yield (Hulke and Kleingartner, 2014). It is an important oil seed crop that can partially fulfill our future requirement and has been successfully grown in range of Pakistan climate.

It requires 8 to 34^{o}C with 120 free frost days. Important districts of Punjab in which it is successfully grown are Gujarat, Okara, Rawalpindi, Lahore, Sargodha, Rajanpur, Faisalabad, Multan, Kasur and D.G. Khan (Shah *et al*., 2005).

Pakistan is facing serious shortage of edible oil because the domestic production is not sufficient to meet total demand. Thus country import edible oil in large quantities involving huge expenditure in foreign exchange. Pakistan cannot afford such amount to import oil. Therefore, it is very important to enhance domestic production of sunflower to meet the increasing demand of edible oils. The area under of sunflower crop in 2012-13 was about 700 thousand acres with oil and seed production of 144 and 378 thousand tons, respectively (GOP, 2013). Sunflower yield in Pakistan is very low as compared to other countries due to less and improper use of fertilization.

All the nutrients are important but nitrogen fertilizer is most important, because nitrogen increase leaf and root length, photosynthesis, leaf area duration and seed yield (Faisal *et al*., 2005). In Pakistan farmers use low nitrogen fertilizer than recommended (Malik *et al*., 2004).

Nitrogen plays an important role in improving growth, quality and yield all crops (Ullah *et al.,* 2010). Sunflower yield can be increased up to 19 to 40% when nitrogen is applied in optimum amount (Zubillaga *et al.,* 2002). Nitrogen fertilizer showed positively linear effect on dry matter production (Rasool *et al.,* 2015). The Pakistani soils show deficiency of nitrogen (Bajwa, 1995). Nitrogen is recommended as essential nutrient for the sunflower, which increased its vegetative seed yield but excessive fertilization of nitrogen causes reduction by increased plant height and lodging (Bailey, 1990). The increase in nitrogen use efficiency by proper management improved seed quality, seed yield, harvest index, farm profit and improved root zone (Shapiro and Wortmann, 2006). So, keeping in mind the importance of nitrogen a field experiment was designed to evaluate influence of different levels of nitrogen on phenology, growth and yield of Sunflower (*Helianthus annuus* L.) hybrid under agro climatic conditions of Sargodha, Pakistan.

Materials and methods

Site and soil

The field experiment was carried out at Research area, College of Agriculture, University of Sargodha, Sargodha. The soil of experimental area was sandy loam and with good drainage capacity. Before sowing of crop analysis of soil was carried out. The Physio-chemical soil analysis of crop area is presented in Table 1.

Experimental design and the treatments

The design of experimental was RCBD with three number of replications. The net plot size was 4 m × 2.80 m. The experiment was laid out under four nitrogen levels and one control. The treatments were comprised of different levels of nitrogen fertilizers (0, 55, 110, 165 and 220 kg ha^{-1}).

Crop husbandry

The seed bed of site was well prepared by cultivating the experimental site for 2-3 times by tractor-mounted cultivator followed by the planking. Hybrid of sunflower was sown on ridge (last week of March

2013; 29/3/2013) by using seed rate of 5 kg ha^{-1} and maintained R×R distance of 70 cm and P×P distance 20 cm. Potassium and Phosphorus fertilizers were applied at the rate of 40 and 80 kg ha^{-1}, respectively in every plot. Sources of Nitrogen, Phosphorus and potassium were Urea, DAP and Potassium (K_2SO_4), respectively. The nitrogen was applied according to the decided treatment. All other practices related to agronomy such as irrigation hoeing, and plant protection were kept normal for every plot.

Observations

Data regarding leaf area index, days to maturity, plant height at maturity (cm), head diameter (cm), no. of achenes per head, 1000-achene weight (g), achene's yield (kg ha^{-1}), total dry matter (kg ha^{-1}) and harvest index (%) was taken. For leaf area index the10 g sample of leaf lamina from each plot was collected and measured their leaf area by leaf area meter (CI-202. Portable Laser Leaf Area Meter) and leaf area index (LAI) was obtained as the ratio of leaf area to the land area (Watson, 1947).

$$\text{LAI} = \frac{\text{Leaf area}}{\text{land area}}$$

For days taken to maturity five plants were randomly selected from every plot and days to maturity was calculated from sowing to harvesting. For measuring the plant height at maturity (cm), ten plants were randomly selected for every treatment and their plant height was taken with the help of meter rod and their average was computed. To measure the head diameter ten plants were selected randomly from every plot and head diameter was measured and calculated average. For the measurement of number of achenes per $head^{-1}$the plants were selected threshed and achenes were separated and average number of achenes $haed^{-1}$ was calculated. For 1000 achenes weight (g), 1000 seeds were taken from seed lot from each plot and weighted by electric balance and average was computed. For achene yield (kg ha^{-1}), the sun dried heads were threshed manually from every plot and seed was cleaned, weight and then converted on tons per hectare basis. Total dry matter was estimated by adding grain and straw yield**.** Harvest index (%) the achene yield was calculated by following formula.

$$\text{H. I (\%)} = \frac{\text{achene yield}}{\text{biological yield}} \times 100$$

Statistical analysis

The data was analyzed by using statistic version 8.1. After analysis of variance, the difference between the treatment means were compared by HSD test at probability level of 5%.

Result and discussion

Leaf area index (LAI)

Leaf area index is basically the ratio of leaf area per unit of land area. Increase in leaf area index increase the capability of crop plant to absorb solar energy and transformed into chemical energy. Moreover, more leaf area index means more area available for photosynthesis and more utilization of natural resources and higher crop growth development and yield. Data regarding leaf area index is given in Table 2. Data shows that LAI was significantly increased by increasing the supply of nitrogen fertilizer.

The application of nitrogen 220 kg ha^{-1} gave the highest value of LAI (4.68) while minimum leaf area index (3.37) was observed where no nitrogen was applied (control treatment). Our results are similar with the findings of Nasim *et al.* (2011) who reported that increase in levels of nitrogen significantly increased the leaf area index.

It might be due to the possible reason that availability of nitrogen fertilizer enhanced the plant LAI and growth because nitrogen is component in vegetative growth (Chaturvedi, 2005).

Table 1. Physio-chemical soil analysis of experimental site.

Soil sample depth	O.M (%)	Soil pH	Total Nitrogen (%)	Available K (mg kg^{-1})	Available P (mg kg^{-1})	Texture
15	1.32	7.9	0.066	164	7.5	Sandy loam

Days to anthesis

The different levels of nitrogen significantly influenced the number of days to anthesis of sunflower hybrid (Table 2). Maximum days taken to anthesis (69.74) was recorded from the plot where nitrogen was applied @ 220 kg ha^{-1} while minimum days to anthesis (64.51) were observed in plot where no nitrogen was applied. Our results of experiment were similar with the findings of Ali *et al.* (2013) who reported that number of days to anthesis was significantly affected due to application of nitrogen fertilizer.

Days to maturity

The maturity of plant plays the most significant role for obtaining the higher yield of crop. Data (Table 2) indicates that plant maturity was significantly affected by the application of different nitrogen levels. The data shows that increase in nitrogen doses significantly increased the days to maturity.

The application of nitrogen @ 220 kg ha^{-1} taken more days to maturity (121.47) and minimum days to maturity (108.60) were observed where no nitrogen was applied (00 kg N ha^{-1}). These findings are in line with the findings of Bakht *et al.* (2006) who reported that increased in nitrogen doses increased the days taken to maturity.

Imran *et al.* (2015) reported that in maize highest value of days to maturity was recorded from the plot where nitrogen was applied @ 210 kg ha^{-1}. This might be due to the fact nitrogen increased the vegetative growth and plants takes more time to mature.

Table 2. Influence of nitrogen application on leaf area index, days to anthesis, days to maturity, plant height (cm) and head diameter (cm) of Sunflower (*Helianthus annuus* L.).

Nitrogen Levels	Leaf Area Index	Days to Anthesis	Days to Maturity	Plant height (cm)	Head diameter (cm)
0 kg ha^{-1}	3.37c	64.51c	108.60c	145.27c	17.02c
55 kg ha^{-1}	3.70bc	65.33c	114.28b	148.95c	18.18bc
110 kg ha^{-1}	4.03b	67.25b	115.70b	157.70bc	22.30abc
165 kg ha^{-1}	4.57a	68.72a	117.81ab	170.48ab	24.57ab
220 kg ha^{-1}	4.68a	69.74a	121.47a	183.67a	25.86a
HSD	0.346	1.199	5.05	18.63	6.70

Plant height at maturity (cm)

The data regarding effect of different levels of nitrogen fertilizer on sunflower plant height is presented in Table 2. Data indicated that treatments differed significantly. 220 kg N ha^{-1} produced the tallest plants (183.67 cm) and 00 kg N ha^{-1} gave minimum plant height. These results are similar with the findings of Ishfaq *et al.* (2009) who concluded that increase in doses of nitrogen significantly increased the plant height. Imran *et al.*, (2015) also reported that application of nitrogen fertilizer at the rate of 210 kg ha^{-1} gave the tallest plant of maize.

The increase in height of plant due to application of nitrogen level probably due to increased availability of nitrogen fertilizer and more leaf area which results in improved photo assimilates and final plant height of plant (Chaturvedi, 2005).

Head diameter (cm)

Head diameter is an important character indicating plant yield. Data regarding head diameter (cm) of sunflower significantly influenced due to the application of treatments is given in Table 2. The maximum size of head diameter (25.86 cm) was recorded in kg 220 kg N ha^{-1} plot which was statistically at par with nitrogen level of 165 kg ha^{-1}. The lowest head diameter (17.02 cm) was noted in control treatment where no nitrogen was applied. These results are supported by the findings of Khaliq and Cheema (2005) who reported that head diameter increased as level of nitrogen fertilizer increases.

Number of achenes per head

The data regarding no. of achenes per head was significantly affected due to application of nitrogen fertilizer (Table 3). Data shows that number of

achenes per head was significantly increased as dose of nitrogen fertilizer increases.

The maximum number of achenes per head (2467) was recorded from the treatment where nitrogen was applied @ 220 kg ha^{-1} and it was statistically at par with nitrogen rate of 165 kg ha^{-1} and the lowest number of achenes per head (981) were noted in control treatment (00 kg N ha^{-1}). Our research findings are in line with the research findings of Mehmood *et al.* (2018) who reported that maximum achenes per head (719.2) were noted at higher doses of nitrogen while lowest number of achenes were observed under controlled conditions. The increase in no. of achenes per head might be due to the fact that plants get more nutrients and more photosynthesis.

Table 3. Influence of nitrogen application on No. of achenes per head, 1000-achenes weight (g), achene yield (kg ha^{-1}), dry matter (kg ha^{-1}) and harvest Index (%) of Sunflower (*Helianthus annuus* L.).

Nitrogen Levels	No. of achenes per head	1000-achenes weight (g)	Achene yield (kg ha^{-1})	Dry matter (Kg ha^{-1})	Harvest Index (%)
0 kg ha^{-1}	981.7d	31.00d	1535.5c	10671b	14.39c
55 kg ha^{-1}	1153.3c	37.00c	1842.7c	11658b	15.80c
110 kg ha^{-1}	1747.7b	43.67b	2422.4b	12565ab	19.28b
165 kg ha^{-1}	2424.0a	56.00a	3356.3a	13679a	24.57a
220 kg ha^{-1}	2467.3a	56.66a	3422.7a	14046a	24.38a
HSD	86.455	5.906	335.14	1906.9	2.595

1000-achenes weight (g)

The statistical data for 1000-achenes weight is depicted in Table 3. Maximum 1000-achenes weight (56 g) was observed in 220 kg N ha^{-1} while the minimum weight of 1000-achenes (31 g) were recorded from control treatment (00 kg N ha^{-1}).

These results are supported by the findings of Mehmood *et al.* (2018) who reported that highest level of 1000-achene weight was recorded at higher concentration of nitrogen and while control gave least value of 1000-achene weight. This might be due to the fact that nitrogen increased the productive and reproductive parts of sunflower and improve nutrients uptake and photosynthesis.

Achene yield (kg ha^{-1})

Data regarding achene yield (kg ha^{-1}) of sunflower significantly affected due to the application of different levels of nitrogen (Table 3). Maximum achene yield (3422 kg ha^{-1}) was recorded from the plot where nitrogen was applied @ 220 kg ha^{-1} and lowest achenes yield (1535 kg ha^{-1}) was noted at 00 kg N ha^{-1} (control conditions). These results are supported by the findings of Akhtar and Malik (2017) who described that increasing level of nitrogen significantly increased the achene yield. This might be due to the fact that application of nitrogen improves leaf area index, crop growth, diameter of head leaf area duration, 1000 weight of achene and finally the achene yield (Abbadi-Gerendas, 2009).

Total dry matter (kg ha^{-1})

The data regarding total dry matter (kg ha^{-1}) affected due to application of nitrogen fertilizer is given in Table 3. Data shows that total dry matter (kg ha^{-1}) was significantly influenced due to the application of treatments. The highest rate of nitrogen fertilizer 220 kg ha^{-1} gave the greatest total dry matter 14046 kg ha^{-1} while lowest dry matter yield was recorded under control conditions (10671 kg ha^{-1}) where no nitrogen was applied. These results are similar with the findings of Nasim *et al.* (2011) who observed strong linear relationship between total dry matter and achene yield. They concluded that as the dose of nitrogen fertilizer increased the dry matter yield also increased. This might be due the fact that nitrogen is involved in vegetative production.

Harvest index (%)

Harvest index percentage is an important parameter which indicates the photosynthetic efficiency of crop and transformation of these Photosynthate into the final economic yield. Data regarding harvest index

(%) affected due to the treatments is presented in Table 3. and data shows that all treatments significantly affected the harvest index of sunflower. The maximum value of harvest index (14.39%) was recorded from the treatment where nitrogen was applied at the rate of 220 kg N ha^{-1} and lowest harvest index (24.38%) was observed under control conditions where no nitrogen fertilizer was applied. These research findings are similar with the findings of Mehmood *et al.* (2018) who observed highest value of harvest index (24.16%) of sunflower at higher dose while lowest harvest index (23.67%) was observed in control. These findings are also supported by the findings of Khaliq and Cheema (2005).

Conclusion

Research findings show that application of nitrogen at the rate of 220 kg ha^{-1} gave maximum leaf area index (LAI), days taken to anthesis, days to maturity, plant height at maturity (cm), head diameter (cm), number of achenes per head, 1000-achenes weight (g), achene yield (kg ha^{-1}), total dry matter (kg ha^{-1}) and harvest index (%) of sunflower. So, it is recommended that application of nitrogen at the rate of 220 kg ha^{-1} is best for maximizing productivity of sunflower under agro-climatic conditions of Sargodha, Pakistan.

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