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Araştırma
(Research)

The Effect of Different Nitrogen Doses on Growth Attributes of Some Sunflower (*Helianthus annuus* L.) Cultivars Grown as Second Crop

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Abstract

Objective: The current study investigated the impact of different N doses on growth traits of some sunflower (*Helianthus annuus* L.) cultivars grown as second crop.

Materials and Methods: The experiment was conducted according to randomized complete block design with split-plot arrangements and three replications. Three sunflower cultivars ('Bosfora', 'P64LE119', and 'LG5582') and four N doses (0, 50, 100, 150, 200 kg ha^{-1} pure N) were included in the study and data relating to different growth traits were recorded.

Results: The results revealed that individual effects of cultivars and N doses exerted significant impacts on the studied growth traits, whereas their interactive effects were significant for some of the studied parameters. The earliest emergence duration was recorded under 150 and 200 kg ha^{-1} N. Similarly, the earliest head formation, flowering initiation and seed filling duration were recorded for 'Bosfora' cultivar with 200 kg ha^{-1} N.

Conclusion: The earliest physiological maturity was recorded for 'P64LE119' cultivar, whereas the widest head diameter and the highest head weight was noted for 'LG5582' cultivar under 200 kg ha^{-1} N application. Overall, 'Bosfora' cultivar under 200 kg ha^{-1} N application performed better for head formation, flowering initiation, and seed filling duration, whereas cultivar 'LG5582' under 200 kg ha^{-1} N application performed better for head diameter and head weight.It is recommended that cultivars 'Bosfora' and 'LG5582' should be provided 200 kg ha^{-1} N for better growth in southeastern Anatolia.

Keywords: Sunflower, nitrogen doses, cultivar, yield, oil ratio

İkinci Ürün Koşullarinda Farkli Azot Dozlarinin Bazi Ayçiçeği (*Helianthus annuus* l.) Çeşitlerinde Büyüme Parametrelerine Etkisinin Belirlenmesi

Öz

Amaç: Bu çalışmada ikinci ürün koşullarında farklı azot dozlarının bazı ayçiçeği (*Helianthus annuus* L.) çeşitlerinde büyüme parametrelerine etkisini araştırmak amacıyla yürütülmüştür.

Materyal ve Yöntem: Çalışma tesadüf bloklarında bölünmüş parseller deneme desenine yürütülmüştür. Ayçiçeği çeşitleri (Bosfora, P64LE119 ve LG5582) ana parselleri, azot dozları (0, 5, 10, 15, 20 kg da^{-1}) ise alt parselleri oluşturmuştur.

Araştırma Bulguları: Çalışmada; denemeye alınan ayçiçeği çeşitlerinin incelenen özelliklerinden, en erken çıkış gün sayısı 15 ve 20 kg da^{-1} N dozlarından, en erken tabla oluşum başlangıcı, çiçeklenme süresi ve tane dolumu gün sayısı Bosfora çeşidinden ve 20 kg da^{-1} N dozundan, en erken fizyolojik olum P64LE119 çeşidinden, en geniş tabla çapı ve en fazla tabla ağırlığı LG5582 çeşidinden ve 20 kg da^{-1} N dozundan elde edilmiştir.

Sonuç: Bu çalışma sonucunda; tabla oluşum başlangıcı, çiçeklenme süresi ve tane dolumu gün sayısı bakımından Bosfora çeşidi ve 20 kg da^{-1} azot dozu, tabla çapı ve tabla ağırlığı bakımından LG5582 çeşidi ve 20 kg da^{-1} N dozu en iyi sonucu vermiştir. Güneydoğu Anadolu Bölgesi için Bosfora ve LG5582 çeşitleri ve 20 kg da^{-1} N verilmesi önerilmektedir.

Anahtar kelimeler: Ayçiçeği, azot dozu, çeşit, verim, yağ oranı

Introduction

The rapid increase in the world population has also increased the demand for food worldwide.

These increase food demands can be fulfilled through either increasing yield per unit area or expanding cultivation areas (Van Dijk et al., 2021). Sunflower is an oilseed crop grown for its edible seeds and oil (Adeleke and Babalola, 2020). Sunflower are grown to produce vegetable oil, snacks, bird seed, and animal feed. Sunflower seed cake left after the oil extraction process, or sunflower hulls are used to prepare animal feed (Sievers, 2023). Wild sunflowers are annual plants with multiple heads and wide branches. However, cultivated sunflowers typically have a single head on an unbranched stem. Sunflower seeds are sold as snack food, either raw or roasted and seasoned with or without salt and spices. The oil extracted from the seeds is used in cooking, margarine production, and biodiesel manufacturing due to its lower cost compared to olive oil. Sunflower can also be used as silage as crude protein content of sunflower silage is higher than corn silage but lower than alfalfa hay (Sievers, 2023). Numerous sunflower cultivars with different fatty acid compositions, and "high oleic" types contain higher levels of monounsaturated fats than olive oil. Sunflower oil is also used in soap and candle manufacturing. The dry stalks of sunflower plants are highly combustible, and their ashes are rich in potassium. Sunflower husks have the same liquid absorption capacity as straw, making them suitable as bedding material for cattle farming. Furthermore, these husks are used in the timber industry as fillers, insulation material, and packaging material (Meral, 2019).

Sunflower is globally cultivated on an area of 27 million hectares, producing 57 million tons seeds with an average yield of 1.608 kg ha^{-1} (FAO, 2021). Sunflower is ranked first among oilseed crops in terms of area under production in Türkiye, and ~62.5% of the vegetable oil is obtained from sunflower in the country (Anonymous, 2022). Sunflower was cultivated on an area of 751.600 ha during 2021 in Türkiye, which produced 2.067 million-ton seeds, with average yield of 2.790 kg ha^{-1}. The average sunflower yield in Türkiye is higher than the global average (FAO, 2021). Sunflower oil consumption in Türkiye is ~950.000 tons, of which 530.000 tons is produced within the country while the remaining 420.000 tons is imported as oilseeds, crude oil, and meal (TÜİK, 2023).

Crop plants uptake different nutrients from the soil, convert them into other compounds or use them as an energy source. Several factors contribute towards obtaining higher crop yields; however, fertilizer management is crucial for better growth and development, and higher productivity of sunflower. Nitrogen (N) is a macronutrient and required in large quantities by crop plants. The N enhances root and leaf length, leaf area, photosynthesis, and ultimately yield (cited in Faisal et al., 2005; Ahmad et al., 2018). Nitrogen aids in the better assimilation of carbohydrates and the synthesis of proteins during early growth stages. It also increases protein content and influences seed quality by reducing fat concentration (Gudade et al., 2009).

Atmosphere is the primary source of N in nature. Soil N content is generally low since N is not naturally present in the soil parent material, and N passed from the atmosphere to the soil is not well retained in the soil. Organic matter is the main reservoir of N in the soil. However, N present in the organic matter is not readily available for plants. Nevertheless, N becomes available for plants as the organic matter decompose. Nitrogen deficiency is prevalent in a significant portion of global soils, and Turkish soils are poor in N due to low organic matter content. Furthermore, N losses from the soil through evaporation and leaching during irrigation are another reason for low N content in Turkish soils. Therefore, N fertilization is continuously required for crop production.

Excessive N application leads to an imbalance between the vegetative and reproductive phases of crop plants, stimulates uncontrolled vegetative growth, and delays plant maturation (Nasim et al., 2016). Sunflower, like other crops, requires N for its optimum growth and development, and higher productivity. Therefore, optimum N dose should be applied to mitigate the decline in soil fertility resulting from climatic conditions and agricultural practices. Different sunflower cultivars respond to N application differently; therefore, N dose must be optimized for each cultivar to achieve higher yield and economic returns (Gao et al., 2012). Furthermore, sunflower cultivars differ in N-use efficiency (NUE). These variations are owed to the ability of plants to stimulate different mechanisms during nutrient uptake and translocation (Fageria et al., 2008). Therefore, optimizing N dose for specific sunflower cultivar is crucial for higher seed yield with early maturity. Additionally, understanding the growth parameters of these varieties is highly important for breeding studies.

This study determined the impacts of different N dosages on growth attributes of sunflower cultivars grown as second crop. It was hypothesized that sunflower cultivars will exhibit significant differences in growth traits under different N doses. The results of the study will optimize N dose for each cultivar and assist in future research relating to improve NUE in sunflower.

Materials and methods

This study was carried out in Field Crops Department Research and Application Area, Faculty of Agriculture, Harran University during summer season of 2017 under second crop conditions. Three oil sunflower cultivars ('Bosfora', 'P64LE119' and 'LG5582') and urea fertilizer (46% N) as N sources were used as materials in the study. Triple super phosphate (42% P_2O_5) was used as phosphorus source in the study.

The experimental soil had clay and clay-loam texture, with 7.92 pH. Organic matter content of the soil is 1.12% (Anonymous, 2017). Some physical and chemical properties of the experimental soil are presented in Table 1.

Table 1. Physico-chemical properties of the experimental soil

Depth (cm)	pH	Organic Matter (%)	EC (ds/m)	Exchangeable cations (me/100 g)			N (%)	Lime ($CaCO_3$) (%)	Texture (%)		
				Ca^{++}	Mg^{++}	K^{+}			Sand	Silt	Clay
0-30	7.92	1.12	3.65	30.32	5.86	8.24	0.12	29.6	24	28	48

Anonymous, 2017

The experimental site is characterized by Mediterranean and continental climate. The summers are hot and dry, while winters are generally mild and rainy due to the influence of the continental climate. The average temperature during sunflower development period (June-November) ranged from 13.4 °C to 34.2 °C, with a long-term average ranging from 13.1 °C to 31.9 °C. The maximum temperatures ranged from 24.5 °C to 44.8 °C, with a long-term average ranging from 30.8 °C to 46.8 °C. The minimum temperatures varied between 2.5 °C and 22.4 °C, while the long-term average ranged from -6 °C to 16 °C. The average rainfall ranged from 0.0 mm to 17.1 mm, with a long-term average ranging from 2.0 mm to 44.3 mm (Figure 1) (TSMS, 2018).

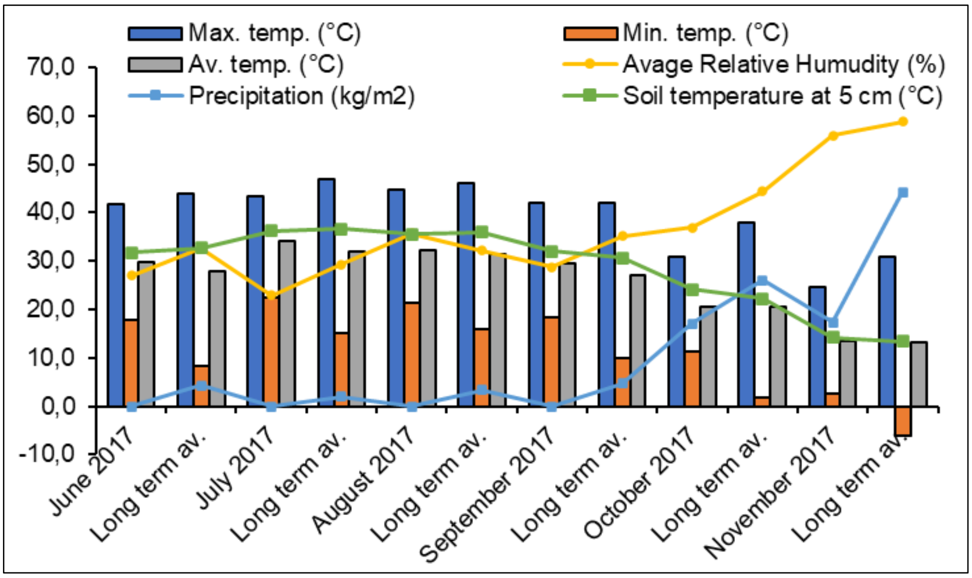

Figure 1. Weather data of Sanliurfa province during the experimental period and long-term climatic conditions prevailing in the region

The average relative humidity ranged from 22.9% to 56.0%, with a long-term average of 29.3% to 58.8%. The soil temperature (5 cm depth) varied between 14.2 °C and 36.2 °C, with a long-term average ranging from 13.4 °C to 36.6 °C (TSMS, 2018).

The experimental site was previously cultivated with wheat, and the field was plowed with a moldboard plow to a depth of 25-30 cm after wheat harvest. Wheat stubbles were broken and pulverized using a disc harrow, followed by harrowing to prepare the soil for sowing sunflower seeds.

The experiment was conducted according to randomized complete block design with split-plot arrangements and three replications. The sunflower cultivars ('Bosfora', 'P64LE119', and 'LG5582') constituted the main plots, while N doses (0, 50, 100, 150, 200 kg ha^{-1}) were randomized in the subplots.

The plantings were done manually on July 11. The plots length was 5 meters, and row-to-row and plant-to-plant distance was maintained at 70 and 25 cm, respectively. Each experimental unit consisted of 4 rows.

The whole amount of phosphorus (80 kg ha^{-1} P_2O_5), and half of the N was applied at the time of sowing. The remaining half N was applied when the plants reached of 25-30 cm height (07.08.2017) and thinning was done at the same time. A gap of 2 m between the plots and 3 m between the blocks was maintained to prevent the transfer of water between the experimental units receiving different N doses.

The plant was irrigated using the furrow (pan) irrigation method. A light irrigation was applied immediately after sowing to ensure germination, followed by another irrigation one week later. Subsequent irrigations (total 5) were applied at 25-30 cm plant height, beginning of head formation, initiation of flowering, and seed filling. Thinning was done when the plants reached a height of 10-15 cm.

Hand hoeing was performed twice based on weed density, during the thinning and earthing up processes. The cultivars used in the experiment were certified and treated with chemicals to control underground pests; therefore, no additional pesticide was applied for pest management as diseases or pest infestation was recorded during the crop development.

Data relating to time required to reach emergence duration (days), head formation (days), flowering initiation (days), seed filling duration (days), and physiological maturity (days) were recorded by counting the days required to initiate each stage. Similarly, head diameter (cm) and head weight (grams) were recorded by following the procedures of Pahlavani (2005).

The collected data were analyzed by two-way analysis of variance (ANOVA) on Minitab. Tukey's honestly significant difference (HSD) post-hoc test was used to compare the means where ANOVA denoted significant differences. The data had normal distribution; therefore, no transformation was done.

Results and Discussion

The results of the ANOVA (F-values) for the investigated growth traits are presented in Table 2.

Table 2. Analysis of variance (F values) for growth traits of different sunflower cultivars used in the current study

Source of Variation	Emergence duration (days)	Head formation (days)	Flowering initiation (days)	Seed filling duration (days)
Cultivars (C)	1.04$^{n.s.}$	49.06**	270.97**	112.34**
Nitrogen Doses (ND)	4.26*	5.78**	11.73**	3.13*
C × ND	0.93$^{n.s.}$	0.63$^{n.s.}$	3.91**	0.66$^{n.s.}$
	Physiological maturity (day)	Head diameter (cm)	Head weight (g)	
Cultivars (C)	13.69**	21.76**	33.79**	
Nitrogen Doses (ND)	1.12$^{n.s.}$	51.36**	9.93**	
C × ND	0.73$^{n.s.}$	1.19$^{n.s.}$	2.59*	

*(p≤0.05), ** (p≤0.01), n.s: not significant

Emergence duration (days)

Different doses of nitrogen significantly changed the emergence duration, whereas cultivars and cultivars by N doses interaction remained non-significant in this regard. The longest (6.67 days) and the shortest (5.78 days) emergence duration was recorded for 0 and 200 kg ha^{-1} N doses, respectively. An earlier study has indicated that N dose significantly influenced the emergence duration of sunflower cultivars (Gül and Kara, 2015). Regarding cultivars, the shortest (5.93 days) and the longest (6.20 days) emergence duration was recorded for the cultivars 'P64LE119' and 'LG5582', respectively (Table 3).

Head formation (days)

The individual effects of cultivars and N doses significantly affected the time required for head formation, whereas their interaction remained non-significant (Table 2). The longest (38.73 days) and the shortest (35.07 days) time to reach head formation was recorded for 'LG5582' and 'Bosfora' cultivars, respectively. Similarly, the longest (38.00 days) and the shortest (36.00 days) time to reach head formation was recorded under 0 and 200 kg ha^{-1} N doses, respectively (Table 3). Although interactive effect was non-significant, the longest (40.00 days) and the shortest (34.33 days) time to reach head formation stage was taken by 'LG5582' × 0 kg ha^{-1} N and 'Bosfora' × 100 kg ha^{-1} N dose, respectively (Table 3).

These results indicated that N applications resulted in early head formation compared to no N application. Hence, N application significantly reduces the time required for head formation.

Flowering initiation (days)

The individual and interactive effects of cultivars and N doses significantly affected the time required for flowering initiation (Table 2). The longest (52.20 days) and the shortest (45.33 days) time for flowering initiation was taken by 'LG5582' and 'Bosfora' cultivars, respectively. Similarly, the plants receiving 0 and 200 kg ha^{-1} N taken the longest (49.56 days) and the shortest (47.22 days) time for flowering initiation, respectively. Regarding interactive effect, 'LG5582' × 0 kg ha^{-1} N and 'Bosfora' × 150-200 kg ha^{-1} N took the longest (54.67 days) and the shortest 45.33 days) time for flowering initiation, respectively (Table 3).

Similar findings indicating that N application shortened the time required for flowering initiation have been reported by Demir (2009) and Day (2011). However, our findings contradict the results reported by Ali et al. (2014), Gül and Kara (2015) and Wabekwa et al. (2015), which suggested that N application significantly delayed flowering. The differences among the results of the current and earlier studies can be attributed to differences in the cultivars used, N doses, and environmental conditions faced by the plants.

Table 3. The impact of individual and interactive effects of sunflower cultivars and nitrogen doses on emergence duration, head formation, flowering initiation, and seed filling durations.

	Emergence duration (days)	Head formation (days)	Flowering initiation (days)	Seed filling duration (days)
Cultivars (C)				
Bosfora	6.07$^{n.s.}$	35.07 c*	45.53 c*	63.27 b*
P64LE119	5.93	36.87 b	46.87 b	64.13 b
LG5582	6.20	38.73 a	52.20 a	74.27 a
Means	6.06	36.89	48.20	67.22
Nitrogen Doses (ND)				
N_o	6.67 a*	38.00 a*	49.56 a*	69.00 a*
N_5	6.00 ab	37.44 ab	48.67 ab	67.78 ab
N_{10}	6.00 ab	36.56 bc	48.11 bc	67.44 ab
N_{15}	5.89 b	36.44 bc	47.44 c	66.22 ab
N_{20}	5.78 b	36.00 c	47.22 c	65.67 b
Means	6.06	36.89	48.20	67.22
C × ND interactions				
Bosfora×N_o	6.67$^{n.s.}$	36.00$^{n.s.}$	45.33 e*	64.33$^{n.s.}$
Bosfora×N_5	6.00	35.67	46.00 e	64.00
Bosfora×N_{10}	6.33	34.33	45.67 e	64.00
Bosfora×N_{15}	5.67	34.67	45.33 e	61.67
Bosfora×N_{20}	5.67	34.67	45.33 e	62.33
P64LE119×N_o	6.67	38.00	48.67cd	65.67
P64LE119×N_5	5.67	38.00	47.33 de	64.00
P64LE119×N_{10}	6.00	36.33	46.00 e	63.33
P64LE119×N_{15}	5.67	36.33	46.33 de	64.33
P64LE119×N_{20}	5.67	35.67	46.00 e	63.33
LG5582×N_o	6.67	40.00	54.67 a	77.00
LG5582×N_5	6.33	38.67	52.67 ab	75.33
LG5582×N_{10}	5.67	39.00	52.67 ab	75.00
LG5582×N_{15}	6.33	38.33	50.67 bc	72.67
LG5582×N_{20}	6.00	37.67	50.33 bc	71.33
Means	6.06	36.89	48.20	67.22
C.V.%	8.30	2.75	1.72	3.32

*Means in a column followed by different letters are statistically different from one another at 95% probability n.s: not significant

Seed filling duration (days)

Seed filling duration was significantly affected by the individual effects of cultivars and N doses, whereas their interaction remained non-significant (Table 2). The longest (74.27 days) and the shortest (63.27 days) seed filling duration was recorded for 'LG5582' and 'Bosfora' cultivars, respectively (Table 3). Similarly, the longest (69.00 days and the shortest

(65.67 days) seed filling duration was recorded under 0 and 200 kg ha^{-1} N doses, respectively (Table 3).

Physiological maturity (days)

Physiological maturity was significantly affected by the individual effects of cultivars, whereas individual effects of N doses and interactive effects of cultivars and N doses remained non-significant in this regard (Table 2). The longest (108.53 days) and the shortest (105.00 days) duration to reach physiological maturity was taken by 'LG5582' and 'P64LE119', respectively (Table 4). Although no statistical difference was noted among N doses, the longest (108.00 days) and the shortest (106.11 days) time to reach physiological maturity was noted under 0 and 200 kg ha^{-1} N application, respectively (Table 4).

The earlier studies indicated that N application significantly affected the physiological maturity in sunflower (Gül and Kara, 2015; Rasool et al., 2015; Wabekwa et al., 2015). However, no significant differences were noted among N doses in the current study. The differences in the results of the current and earlier studies can be attributed to different cultivars, N doses, planting time, and climate conditions in earlier studies.

Table 4. The impact of individual and interactive effects of sunflower cultivars and nitrogen doses on physiological maturity, head diameter and head weight

	Physiological maturity (days)	Head diameter (cm)	Head weight (g)
Cultivars (C)			
Bosfora	107.67 a*	18.96 b*	68.61 b*
P64LE119	105.00 b	18.32 c	66.85 b
LG5582	108.53 a	19.68 a	73.52 a
Average	107.07	18.99	69.66
Nitrogen Doses (ND)			
N_o	108.00$^{n.s.}$	17.36 d*	66.57 c*
N_5	107.22	18.22 c	68.63 bc
N_{10}	106.89	19.00 bc	69,28 bc
N_{15}	107.11	19.38 b	70.76 ab
N_{20}	106.11	20.95 a	73.05 a
Average	107.07	18.99	69.66
C × ND interactions			
Bosfora×N_o	107.67$^{n.s.}$	17.74$^{n.s.}$	68.61 bcde
Bosfora×N_5	109.00	18.43	67.15 cde
Bosfora×N_{10}	107.33	18.63	66.14 de
Bosfora×N_{15}	107.00	19.24	69.03 abcde
Bosfora×N_{20}	107.33	20.73	72.09 abcd
P64LE119×N_o	106.33	16.20	63.36 e
P64LE119×N_5	105.33	17.51	65.38 de
P64LE119×N_{10}	104.67	18.48	66.26 de
P64LE119×N_{15}	105.67	18.68	67.27 cde
P64LE119×N_{20}	103.00	20.73	71.96 abcd
LG5582×N_o	110.00	18.15	67.74 cde
LG5582×N_5	107.33	18.73	73.35 abc
LG5582×N_{10}	108.67	19.88	75.44 ab
LG5582×N_{15}	108.67	20.22	75.98 a
LG5582×N_{20}	108.00	21.40	75.10 ab
Average	107.07	18.99	69.66
C.V.%	1.80	2.97	5.33

*Means in a column followed by different letters are statistically different from one another at 95% probability n.s: not significant

Head diameter (cm)

Head diameter was significantly affected by individual effects of cultivars and N doses, whereas their interactive effect was non-significant (Table 2). The largest (19.68 cm) and the smallest (18.32 cm) head diameter was recorded for 'LG5582' and 'P64LE119' cultivars, respectively (Table 4). Similarly, 0 and 200 kg ha^{-1} N doses resulted in the smallest (17.36 cm) and the largest (20.95 cm) head diameter, respectively (Table 4).

Gürbüz et al. (2003) reported that head diameter in sunflower significantly varies depending on ecological conditions, soil structure, cultivation techniques, irrigation status, and cultivar factors. Significant effect of N dose on head diameter have also been reported by several earlier studies (Day, 2011; Ali et al., 2014; Day and Kolsarıcı, 2014; Rasool et al., 2015; Kandil et al. 2017; Bjaili et al., 2019).

Head weight (g)

The individual and interactive effects of cultivars and N doses significantly altered head weight (Table 2). The lowest (66.85 g) and the highest (73.52 g) head weight was recorded for 'P64LE119' and 'LG5582' cultivars, respectively. Similarly, 0 and 200 kg ha^{-1} N doses resulted in the lowest (66.57 g) and the highest (73.52 g) head weight, respectively. Regarding interaction, 0 kg ha^{-1} N × 'P64LE119' and 150 kg ha^{-1} × 'LG5582' resulted in the lowest (63.36 g) and the highest (75.98 g) head weight, respectively (Table 4). The results of the current study agree with Oshundiya et al. (2014).

Conclusion

The earliest emergence was recorded under 150 and 200 kg ha^{-1} N doses. The shortest time to reach head formation and earliest flowering initiation was recorded for 'Bosfora' cultivar receiving 200 kg ha^{-1} N application. The shortest seed filling duration was recorded for 'Bosfora' cultivar. The earliest physiological maturity was noted in 'P64LE119' cultivar. The largest head diameter and head weight was recorded for 'LG5582' cultivars receiving 200 kg ha^{-1} N.

A thorough understanding of optimum N dose for different sunflower cultivars is crucial for achieving higher seed yield. Furthermore, studying the impact of different N doses on growth parameters is highly important for breeding programs. The results of the current study revealed that 'Bosfora' cultivar with 200 kg ha^{-1} N performed better for head formation, flowering initiation, and seed filling duration. On the other hand, 'LG5582' cultivar with 200 kg ha^{-1} N performed better for head diameter and head weight. It is recommended that 200 kg ha^{-1} N doses is optimum for 'Bosfora' and 'LG5582' cultivars.

Conflicts of Interest

The authors declare no conflicts of interest.

Author Contribution

HH: Determination of the trial site, contribution to the implementation of agricultural practices, statistical analysis of the article, writing, and submission to the journal.

AA: Conducting the trial, contributing to the maintenance procedures, and performing measurements.

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