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Responses of Linoleic and High Oleic Type Sunflower Varieties (*Helianthus Annuus* L.) to Nitrogen and Potassium Applications

Linoleik ve Yüksek-Oleik Tip Ayçiçeği Çeşitlerinin Azot ve Potasyum Uygulamalarına Tepkileri

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ABSTRACT

Objective: The study was conducted to determine the effects of nitrogen (N) and potassium (K) on dry matter and some nutrient elements uptake of linoleic and high-oleic type sunflower varieties.

Material and Methods: A greenhouse experiment was carried out in randomized factorial design with three replicates, 0, 16, 32, 48, and 64 mg kg^{-1} N and 0, 24, and 48 mg kg^{-1} K were applied.

Results: Dry matter and nutrient uptake of sunflower varieties increased with nitrogen ($p<0.01$), however decreased with potassium. The highest amounts were obtained from 32 mg kg^{-1} N dose and ESGrafic CL variety.

Conclusion: High-oleic type sunflower varieties have resulted in more fertilizer requirements.

Keywords:

Sunflower, nitrogen, potassium, plant nutrients

ÖZ

Amaç: Çalışma, azot (N) ve potasyum (K) uygulamalarının linoleik ve yüksek oleik tip ayçiçeği çeşitlerinin kuru madde ve kimi besin elementi içeriklerine etkisini belirlemek amacıyla yürütülmüştür.

Materyal ve Metot: Serada tesadüf parselleri faktöryel deneme deseninde üç tekerrürlü olarak yürütülen denemede 0, 16, 32, 48, 64 mg kg^{-1} N ve 0, 24, 48 mg kg^{-1} K uygulanmıştır.

Bulgular: Ayçiçeği çeşitlerinin kuru madde ve besin elementi alınımı azot dozları ile artmış ($p<0.01$), potasyumla birlikte azaltmıştır. En yüksek değerler azotun 32 mg kg^{-1} dozundan ve ESGrafic CLçeşidinden elde edilmiştir.

Sonuç: Yüksek oleik tip ayçiçeği çeşitlerinin daha fazla gübre gereksinimleri olduğu sonucuna varılmıştır.

Anahtar Sözcükler:

Ayçiçeği, azot, potasyum, bitki besin elementleri

INTRODUCTION

In recent years, the production and consumption of high oleic acid-containing sunflower (*Helianthus annuus* L.) has become a preferred option due to the understanding of their benefits to human health (Zheljazkov et al., 2011). Studies have shown that the composition of the sunflower oil is genetic and it has shown that it also depends on the environmental conditions (Karaca and Aytaç, 2007; Zheljazkov et al., 2011). The role of environment such as temperature, location, sawing time, watered or dry conditions, and soil properties on the performance of genotypes is of great importance (Karaca and Aytaç, 2007). Different cultivars grown on different cultures may have different agronomic performances (Zheljazkov et al., 2011; Tan, 2014). In order to determine the performances of the varieties, lots of research results which were conducted at different ecological locations with different varieties, indicated different values of grain yield and agronomic characters (Tan et al, 2000; Kaya et al., 2003; Tozlu et al., 2008; Tan et al., 2013; Tan, 2014). Fertilization of the soil has also a great importance to gain high and quality yield (Gül and Kara, 2015). Adequate amounts of nutrient elements in the soil will feed the plants and it will help the yield and quality of the seeds and the oil.

Nitrogen is one of the most important nutrient elements, enhances the metabolic processes that affects the vegetative and generative stages of the plants and increases the yield and quality of the plants while applied at optimum concentrations (Ceylan et al., 2001; Škarpa and Lošák, 2008; Massignam et al., 2009; Ullah et al., 2010; Banerjee et al., 2014, Biswas and Poddar, 2015). Potassium is also regarded as one of the major nutrient elements that affect the yield and quality of grains. It takes an essential role in plant metabolism, activates several enzymes, regulates the opening of the stomata and water consumption of the plants and balances the charges of anions (Mengel, 2007; Celik et al.2010; Yağmur and Okur, 2017).

Understanding the response of the new developed varieties to the nitrogen and potassium applications and uptake of the nutrients is important for balanced fertilization and to gain high and quality products. Therefore, this study was conducted to determine the dry matter and nutrients uptake, and find out the nutritional differences of linoleic and high-oleic type sunflower cultivars under increasing nitrogen and potassium applications.

MATERIAL AND METHODS

A greenhouse experiment was conducted in randomized factorial design with three replicates. The soil sample used in the experiment was collected from 0–20 cm deep in a field located at the Agricultural Research and Application Centre of Uludag University (40°15' 21.6" N 28° 50' 55.7" E) in Turkey. Some properties of the soil are shown in Table 1. Özsoy and Aksoy (2013) classified the soil as vertisol (*Typic Haploxerert*) according to the soil taxonomy and as eutric vertisol according to the FAO classification system. The soil used in the experiment had a clay texture and slightly alkaline pH. Additionally, it had low lime content and EC. The soil also had low concentrations of organic matter, adequate nitrogen, phosphorus, potassium, zinc, manganese (Mn) and boron. The concentrations of the other nutrient elements, such as calcium, magnesium (Mg), iron (Fe) and copper were found to be high (Table 1).

Air-dried soil was passed through a 4 mm sieve and 3.5 kg of the soil placed into each of the polyethylene covered plastic pots. Increasing nitrogen doses (Control, 16, 32, 48 and 64 mg kg^{-1} N) and increasing potassium doses (Control, 24 and 48 mg kg^{-1} K) were applied to the soil. Phosphorus (P) concentrations of the whole pots were remained at a constant value of 19 mg kg^{-1} P. Nitrogen was supplied from ammonium nitrate (NH_4NO_3) (Extra pure, Merck, Germany). For the pots containing 24 mg kg^{-1} K and 19 mg kg^{-1} P were supplied from monopotassium phosphate (KH_2PO_4) (Emprove, Merck, Germany) and for the pots containing 48 mg kg^{-1} K and 19 mg kg^{-1} P were supplied from dipotassium hydrogen phosphate (K_2HPO_4) (Emprove, Merck, Germany). For the control pots that contain no potassium; phosphoric acid (H_3PO_3) were used to supply the 19 mg kg^{-1} P.

Table 1. Some properties of the soil used in the research

Çizelge 1. *Araştırmada kullanılan toprağın kimi özellikleri*

Properties	Quantities	Properties	Quantities
Texture	Clay	Extractable cations, (mg kg^{-1})	
Sand (%)	35.84	Sodium (Na)	121
Silt (%)	17.64	Potassium (K)	203
Clay (%)	46.52	Calcium (Ca)	8437
pH	7.89	Magnesium (Mg)	495.6
EC (mS cm^{-1})	0.27	Extractable microelements, (mg kg^{-1})	
Lime (% $CaCO_3$)	1.16	Iron (Fe)	9.59
Organic matter (%)	1.63	Copper (Cu)	1.52
Total nitrogen (N) (%)	0.09	Zinc (Zn)	1.75
Available sulphur (S) (mg kg^{-1})	11.19	Manganese (Mn)	18.71
Available phosphorus (P) (mg kg^{-1})	15.66	Boron (B)	1.44

Four sunflower (*Helianthus annuus* L.) seed cultivars "ESNovamis CL, LG 5542 CL, Oliva CL, ESGrafic CL" were used and five seeds were planted in each pot, which were 20 cm in diameter and 18 cm deep, and two plants were left in each pot after germination. The water content of the pots was adjusted to 70% of the field capacity during the experiment. After 35 days, the sunflower shoots were cut over the soil level and then immediately transferred to the laboratory. In order to avoid possible contamination from dust, the samples were washed in tap water and twice with deionized water. The samples were dried in a hot air oven (Nuve KD 400, Turkey) at 70°C for 72 h, weighed and then ground using a laboratory mill (Foss CT 193 cyclotec, Denmark) passing through 0.5 mm sieve. For the evaluation of the nutrient uptake in shoots, 0.2 g of the ground samples were digested using a mixture of 3 mL of nitric acid (HNO_3) (65 %, Emplura, Merck) and 3 mL of hydrogen peroxide (H_2O_2) (35 %, Emprove exp, Merck) in a microwave oven (Berghof MWS 2, Germany) (Hansen et al. 2013). Magnesium (Mg), and phosphorus (P) amounts were determined by inductively coupled plasma-optical emission spectrometry (ICP-OES) (Perkin Elmer Optima 2100DV, USA) (Hansen et al. 2013). Na, K and Ca were determined by the flame emission (Eppendorf Elex 6361) (Eppendorf-Hamburg/Germany) (Horneck and Hanson, 1998). Total nitrogen was determined by Kjeldahl method (Buchi K-437, K-350) (Buchi-Flawil/Switzerland). Data from all of the experiments were subjected to statistical analysis and the mean values were compared using the least significant difference (LSD) multiple range test with the computer program MINITAB 17.1.0.0 (Minitab Inc., State College, Pennsylvania, USA).

RESULTS

Effects of increasing application doses of nitrogen and potassium on dry weight of sunflower varieties were shown on Table 2. According to the statistical analysis results, nitrogen and potassium applications effected the dry weight amounts of sunflower varieties significantly ($p<0.01$). Increasing doses of nitrogen elevated the dry weight amounts up to 32 mg kg^{-1} N application dose and the highest dry weight was determined as 11.42 g pot^{-1}. Increasing the nitrogen amounts over this indicated dose decreased the dry weight; however the least dry weight was determined from the control (10.21 g pot^{-1}). In contrast to nitrogen increasing the potassium decreased the dry weight of sunflower varieties. The highest dry weight (12.26 g pot^{-1}) was determined at control however, the lowest amount was found at the highest potassium dose (10.11 g pot^{-1}). A statistically important difference was also determined between the varieties ($p<0.01$). The highest dry weight was determined from ESGrafic CL variety (12.20 g pot^{-1}) and placed in the same group with Oliva CL (12.02 g pot^{-1}). Although high-oleic type sunflower varieties had higher dry weight amounts, the dry matter amounts of linoleic type varieties ESNovamis CL and LG5542 CL (9.89-9.21 g pot^{-1}) were not found as high as the indicated high oleic type sunflower varieties.

Effects of increasing application doses of nitrogen and potassium on nitrogen uptake of sunflower varieties were shown on Table 3. Nitrogen uptake of the sunflower varieties were affected statistically from the increasing nitrogen doses ($p<0.01$). Increasing doses of nitrogen elevated the uptake of nitrogen and the highest amount (213.62 mg pot^{-1}) was determined at the highest application dose (64 mg kg^{-1} N). Increasing the potassium doses decreased the uptake of nitrogen and the lowest amount was determined at control (196.65 mg pot^{-1}). A significant difference between the varieties were determined according to the applications ($p<0.01$). The highest nitrogen uptake was determined from ESGrafic CL variety (196.03 mg pot^{-1}) and ESNovamis CL (195.33 mg pot^{-1}) was observed with in the same group.

Effects of increasing application doses of nitrogen and potassium on potassium uptake of sunflower varieties were shown on Table 4. According to the statistical analysis results, nitrogen and potassium applications effected the uptaken potassium amounts of sunflower varieties significantly ($p<0.01$). Increasing doses of nitrogen elevated the potassium amounts up to 32 mg kg^{-1} N application dose and the highest potassium uptake was determined as 334.87 mg pot^{-1}. Increasing the nitrogen over this indicated dose, decreased the potassium uptake; however the least potassium amount was determined from the control (289.70 mg pot^{-1}). In contrast to nitrogen increasing the potassium doses decreased the uptaken potassium amounts of sunflower varieties. The highest potassium uptake (364.71 mg pot^{-1}) was determined at control however, the amounts were found lower than control at the potassium doses respectively (289.23 mg pot^{-1} and 289.59 mg pot^{-1}). A statistically important difference was also determined between the varieties ($p<0.01$). The highest potassium uptake was determined from ESGrafic CL variety (331.38 mg pot^{-1}) and Oliva CL (329.04 mg pot^{-1}) followed it. Although high-oleic type sunflower varieties had higher potassium uptake, the results of linoleic type varieties ESNovamis CL and LG5542 CL (311.08-286.55 mg pot^{-1}) were not found as high as the indicated high oleic type sunflower varieties.

Statistically significant effects of increasing application doses of nitrogen was determined on the phosphorus (P), calcium (Ca), and magnesium (Mg) uptake ($p<0.01$) of sunflower (Table 5, 6 and 7). The highest amounts of P (35.51 mg pot^{-1}) were taken from the second application dose of nitrogen (32 mg kg^{-1}). Although they were within the same group, the highest amount of Ca uptake (196.08 mg pot^{-1}) was observed at the third application dose of nitrogen (48 mg kg^{-1}). Magnesium uptake (43.83 mg pot^{-1}) was also found high at the third nitrogen dose. A reduction was occurred on the uptaken phosphorus, calcium and magnesium amounts of the sunflower varieties with the increasing potassium. Among the varieties a statistically significant difference ($p<0.01$) was also determined. The highest P uptake was observed from Oliva CL and ESGrafic CL variety. ESGrafic CL which is known as high oleic type sunflower has also the highest uptaken Ca and Mg amounts.

Table 2. Effects of Nitrogen and Potassium Doses on Dry Matter Yield of Sunflower Varieties.
Çizelge 2. *Azot ve Potasyum Dozlarının Ayçiçeği Çeşitlerinin Kuru Madde Verimine Etkileri*

		Nitrogen Doses mg kg^{-1}										Mean	
		0		16		32		48		64			
Potassium Doses mg kg^{-1}	0	11.35		12.64		12.70		12.60		12.03		12.26	a
	24	9.51		10.45		10.91		10.08		9.59		10.11	b
	48	9.76		10.44		10.66		10.30		9.41		10.11	b
	Mean	**10.21**	**B**	**11.17**	**A**	**11.42**	**A**	**11.00**	**A**	**10.34**	**B**		
Varieties													
ESNovamis CL	0	9.59		11.15		11.65		11.21		10.83		10.88	a
	24	8.53		9.49		9.72		9.25		8.65		9.13	b
	48	9.39		9.67		10.79		9.66		8.77		9.66	b
	Mean	**9.17**		**10.10**		**10.72**		**10.04**		**9.42**		**9.89**	**b**
LG 5542 CL	0	10.12		10.77		10.55		10.54		10.59		10.52	a
	24	8.14		9.31		8.90		7.81		8.02		8.44	b
	48	9.28		9.17		9.33		8.39		7.15		8.66	b
	Mean	**9.18**		**9.75**		**9.59**		**8.91**		**8.59**		**9.21**	**c**
Oliva CL	0	12.69		14.36		14.04		13.69		12.92		13.54	a
	24	10.29		11.57		12.80		11.33		10.00		11.20	b
	48	10.09		11.83		11.90		12.21		10.61		11.33	b
	Mean	**10.02**		**12.59**		**12.91**		**12.41**		**11.18**		**12.02**	**a**
ESGrafic CL	0	12.98		14.27		14.57		14.97		13.78		14.12	a
	24	11.06		11.42		12.21		11.95		11.69		11.67	b
	48	10.30		11.07		10.62		10.94		11.10		10.81	c
	Mean	**11.45**		**12.25**		**12.47**		**12.62**		**12.19**		**12.20**	**a**

The differences between values by different letters are significant. Capital letters for each row and small letters for each column.

$V_{LSD\ p<0.01}$	0.573	$K_{LSD\ p<0.01}$	0.496	$N_{LSD\ p<0.01}$	0.641
$VxK_{LSD\ p<0.05}$	0.751	VxN_{LSD}	ns	KxN_{LSD}	ns
$VxKxN_{LSD}$	ns				

V:Varieties K:Potassium Doses N: Nitrogen Doses ns : not significant

Table 3. Effects of Nitrogen and Potassium Doses on Nitrogen Uptake of Sunflower Varieties.
Çizelge 3. *Azot ve Potasyum Dozlarının Ayçiçeği Çeşitlerinin Azot Alımına Etkileri*

		Nitrogen Doses mg kg^{-1}										Mean	
		0		16		32		48		64			
Potassium Doses mg kg^{-1}	0	146.33	C b	177.43	B a	196.23	B a	225.96	A a	237.30	A a	196.65	a
	24	168.43	C a	179.99	BC a	197.07	B a	198.98	B b	219.50	A a	192.79	ab
	48	168.95	B a	188.23	A a	196.76	A a	187.91	AB b	184.05	AB b	185.18	b
	Mean	**161.24**	**D**	**181.88**	**C**	**196.69**	**B**	**204.28**	**AB**	**213.62**	**A**		
Varieties													
ESNovamis CL	0	156.02	C a	185.09	BC a	212.27	AB a	224.18	A a	231.65	A a	201.84	a
	24	172.62	B a	191.52	AB a	195.74	AB a	212.05	A a	217.07	A a	197.80	ab
	48	179.40	B a	179.74	B a	214.16	A a	175.32	B b	183.13	B b	186.35	b
	Mean	**169.35**	**B a**	**185.45**	**B a**	**207.39**	**A a**	**203.85**	**A ab**	**210.62**	**A bc**	**195.33**	**a**
LG 5542 CL	0	143.14	D b	167.23	CD b	183.05	BC a	210.89	AB a	217.06	A a	184.27	a
	24	157.95	B ab	194.66	A ab	193.42	A a	185.45	AB ab	186.88	AB b	183.67	a
	48	172.56	B a	200.98	AB a	208.34	A a	180.90	AB b	180.42	AB b	188.64	a
	Mean	**157.88**	**B a**	**187.63**	**A a**	**194.94**	**A ab**	**192.41**	**A b**	**194.79**	**A c**	**185.53**	**b**
Oliva CL	0	149.51	C a	180.93	B ab	182.71	B a	232.69	A a	260.54	A a	201.28	a
	24	160.37	C a	155.85	C b	198.49	AB a	182.25	BC b	221.33	A b	183.66	b
	48	149.17	C a	190.86	AB a	182.85	B a	217.99	A a	173.58	BC c	182.89	b
	Mean	**153.02**	**C a**	**175.88**	**B a**	**188.02**	**B b**	**210.98**	**A a**	**218.48**	**A ab**	**189.28**	**ab**
ESGrafic CL	0	136.65	D b	176.46	C a	206.89	B a	236.09	A a	239.96	A a	199.21	a
	24	182.77	C a	177.91	C a	200.63	BC a	216.16	B a	252.70	A a	206.04	a
	48	174.68	A a	181.35	A a	181.70	A a	177.42	A b	199.06	A b	182.84	b
	Mean	**164.70**	**C a**	**178.57**	**C a**	**196.41**	**B ab**	**209.89**	**B a**	**230.57**	**A a**	**196.03**	**a**

The differences between values by different letters are significant. Capital letters for each row and small letters for each column.

$V_{LSD\ p<0.05}$	7.518	$K_{LSD\ p<0.01}$	8.607	$N_{LSD\ p<0.01}$	11.111
$VxK_{LSD\ p<0.05}$	13.021	$VxN_{LSD\ p<0.05}$	16.811	$KxN_{LSD\ p<0.01}$	19.245
$VxKxN_{LSD\ p<0.05}$	29.117				

V:Varieties K:Potassium Doses N: Nitrogen Doses ns : not significant

Table 4. Effects of Nitrogen and Potassium Doses on Potassium Uptake of Sunflower Varieties.
Çizelge 4. *Azot ve Potasyum Dozlarının Ayçiçeği Çeşitlerinin Potasyum Alımına Etkileri*

		Nitrogen Doses mg kg^{-1}					Mean
		0	16	32	48	64	
Potassium Doses mg kg^{-1}	0	324.32	376.94	383.56	383.67	355.08	364.71 a
	24	269.52	297.67	318.40	282.90	277.66	289.23 b
	48	275.26	296.14	302.64	302.05	271.86	289.59 b
	Mean	**289.70 B**	**323.58 A**	**334.87 A**	**322.87 A**	**301.53 B**	
Varieties							
ESNovamis CL	0	324.95	344.70	377.37	337.34	318.12	340.50 a
	24	302.83	305.09	303.92	290.29	252.55	290.94 b
	48	288.05	305.77	328.78	304.98	281.43	301.81 b
	Mean	**305.28**	**318.52**	**336.69**	**310.87**	**284.03**	**311.08 b**
LG 5542 CL	0	309.50	367.18	310.57	345.73	329.59	332.52 a
	24	241.63	283.99	285.53	230.13	243.70	257.00 b
	48	257.60	271.69	303.42	273.93	243.97	270.12 b
	Mean	**269.58**	**307.62**	**299.84**	**283.27**	**272.42**	**286.55 c**
Oliva CL	0	331.16	382.25	412.56	443.31	396.57	393.17 a
	24	241.15	271.78	347.12	294.39	292.45	289.38 b
	48	297.88	319.08	290.75	335.82	279.38	304.58 b
	Mean	**290.06**	**324.37**	**350.14**	**357.84**	**322.80**	**329.04 ab**
ESGrafic CL	0	331.66	413.64	433.72	408.31	376.04	392.67 a
	24	292.45	329.80	337.04	316.77	321.96	319.60 b
	48	257.50	288.03	287.62	293.46	282.65	281.85 c
	Mean	**293.87**	**343.82**	**352.79**	**339.52**	**326.88**	**331.38 a**

The differences between values by different letters are significant. Capital letters for each row and small letters for each column.

$V_{LSD\ p<0.01}$	18.944	$K_{LSD\ p<0.01}$	16.406	$N_{LSD\ p<0.01}$	21.180
$VxK_{LSD\ p<0.05}$	32.812	VxN_{LSD}	ns	KxN_{LSD}	ns
$VxKxN_{LSD}$	ns				

V:Varieties K:Potassium Doses N: Nitrogen Doses ns : not significant

DISCUSSION

Nitrogen is known as the most yield limiting nutrient because of its efficiency on photosynthesis (Ciobanu et al., 2008; Banerjee et al., 2014) and partitioning into various parts of crop plants for growth, development and other processes (Bozkurt and Karaçal, 2000; Khaliq and Cheema, 2005; Škarpa and Lošák, 2008; Banerjee et al., 2014). It is an important component of chlorophyll and other bio-catalytic substances (Škarpa and Lošák, 2008). In the light of the literatures, in our research results application of the increasing doses of Nitrogen also affected the dry matter production as well as N accumulation of the sunflower. Supporting the findings of us, Yadav et al. (2009) also reported the increases on the biomass of the plant as a result of elevated nitrogen uptake and a greater absorption of all the nutrients from soil. However, high doses of applied nitrogen decreased the dry matter and also the other nutrients uptake (Škarpa and Lošák, 2008; Biswas and Poddar, 2015).

Sunflower is a deep rooted fast growing crop and responds to fertilizer applications under low nutrient soil conditions and was reported 8.8 kg da^{-1} N, 1 kg da^{-1} P and 5.4 kg da^{-1} K removals occur for 180 kg da^{-1} seed production (Shyamkiran, 2000; Banerjee et al., 2014). Hegde and Sudhakarababu, (2009) declined the amounts 6.3 kg da^{-1} N, 1.9 kg da^{-1} P_2O_5 and 12.6 kg da^{-1} K_2O for 100 kg da^{-1} seed production. Inappropriate, unbalanced, excess or low use of fertilizers in sunflower may lead to poor uptake, wasting the resources and potential environmental damage (Hawkesford, 2012; Banerjee et al., 2014). In the previous field studies, 4 to 24 kg da^{-1} N were reported as generally applied nitrogen doses to sunflower (Gül and Kara, 2015; Sheoran et al., 2016; Nasim et al., 2016; Nasim et al., 2017; Yağmur and Okur, 2017). In our study nitrogen doses applied to pots were found in the range of these previous field researches. Applications of nitrogen increased the dry matter production, and 32 mg kg^{-1} N dose which was equivalent of the 8 kg da^{-1} N at field conditions had the highest dry matter amount. Various doses were presented at the previous research results, depending to the differences on ecological conditions, managements, and plant species and also inspected parameters. Gül and Kara (2015) reported the efficient nitrogen dose as 3 kg da^{-1} for plant height, oil content and oil yield, 9 kg da^{-1} for harvest index and 12 kg da^{-1} for protein content. Oyinlola et al. (2010), Biswas and Poddar (2015), and Sheoran et al. (2016) reported the nitrogen doses up to 10 kg da^{-1}, required for satisfactory level yield in hybrid sunflower. Ravishankar and Malligawad (2017) reported this amount as 12.6 kg da^{-1}. According to the research results, higher dry matter amounts were recorded in relation to increased photosynthesis rate in sunflower plants grown in sufficient N conditions. However, it was also reported that higher application doses than sufficiency level decrease the dry matter yield (Škarpa and Lošák, 2008; Dordas and Sioulas, 2009; Nasim et al, 2011; Krishnamurthy et al., 2011; Banerjee et al., 2014; Biswas and Poddar, 2015; Ravishankar and Malligaward, 2017).

Nitrogen uptake elevated due to the increased doses of nitrogen and previous researches drew similar conclusions (Škarpa and Lošák, 2008; Biswas and Poddar, 2015). Bozkurt and Karaçal, (2000) reported increases on nitrogen contents of sunflower varieties due to the 0-12 kg da^{-1} nitrogen application doses.

With the application of potassium in increasing quantities, dry matter yield of the sunflower was affected negatively. Similarly, Gerendas et al. (2008) reported that high potassium levels in the study of sunflower and aspire caused a fall in productivity. Gheorghe et al. (2011) reported an increase in the yield of sunflower with 8 kg da^{-1} potassium application in Romania. In our experiment, we applied 24-48 mg kg^{-1} K; corresponds to about 6-12 kg da^{-1} K in field conditions and the dose indicated in the literature shows that the increase in yield was observed among the doses we applied. However, because of having sufficient amounts of potassium in our experimental soil, its effect was found negative. Sağlam et al. (1992) in the sunflower experiment where they carried out a medium potassium containing area in order to determine the potassium requirement of the sunflower plant grown in the Tekirdağ region; they applied 5 kg of N and 5 kg of P_2O_5 and 0, 2.5, 5, 7.5, 10 and 12.5 kg of K_2O da^{-1} potassium. According to the results obtained for two years, it was reported that 2.5 kg of K_2O da^{-1} dose was sufficient for the maximum product, while the subsequent doses did not increase the yield. Ciobanu et al. (2008), in their work with sunflower plants; 0, 8, 16 kg N da^{-1}; 0, 4, 8 kg of P_2O_5 da^{-1}; and 0, 4, 8, 12 kg K_2O da^{-1} they applied to the soil, and reported the highest yield at 8 kg K_2O da^{-1} fertilizer doses. They pointed out that in the case of further application of potassium, the current increase is not economical and that the benefit from potassium applications is related to the doses of nitrogen and phosphorus. The results in the literature have been found to support the results we have experimentally obtained.

Nutrient contents of the sunflower were also affected by cultivars. Increased nitrogen applications had also influenced the nutrients uptake of sunflower varieties. Different cultivars grown on different cultures may have different agronomic performances (Zheljazkov et al., 2011; Tan, 2014). In order to determine the performances of the varieties, lots of research results which were conducted at different ecological locations with different varieties, indicated different values of grain yield, nutrient uptake and agronomic characters (Tan et al, 2000; Kaya et al., 2003; Tozlu et al., 2008; Tan et al., 2013; Tan, 2014). Abdel-Motagally and Osman (2010) reported that sunflower varieties react differently to nitrogen and potassium applications as a result of the study. Similar results were also obtained by Basha (2000).

CONCLUSION

Significant effects of nitrogen application doses were found on dry matter and nutrient uptake of sunflower varieties. Increasing doses of nitrogen elevated the dry weight, nitrogen and other nutrients uptake of all tested sunflower varieties. The increases were found maximum at 32 mg kg^{-1} N dose. A significant difference was also found between the varieties according to the amounts of the dry matter and nutrients uptake. The up taken amounts of the nutrients were found higher at high-oleic type than the linoleic type sunflower varieties. Among the varieties Especially ESGrafic CL one of the high-oleic type sunflower variety, was selected as the variety which has a higher nutrient uptake capacity than the others. It can concluded that because of their high fertilizer needs, much more attention must be paid while fertilizing the new generation high-oleic type hybrid sunflower varieties due to the soil and plant analysis results.

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Table 5. Effects of Nitrogen and Potassium Doses on Phosphorus Uptake of Sunflower Varieties.
Çizelge 5. *Azot ve Potasyum Dozlarının Ayçiçeği Çeşitlerinin Fosfor Alımına Etkileri*

		Nitrogen Doses mg kg^{-1}										
		0		16		32		48		64		Mean	
Potassium Doses mg kg^{-1}	0	36.43		40.42		39.49		41.70		38.28		39.26	a
	24	26.87		30.95		33.86		30.89		29.89		30.49	b
	48	29.92		31.67		33.18		32.26		29.43		31.29	b
	Mean	**31.07**	**C**	**34.35**	**AB**	**35.51**	**A**	**34.95**	**A**	**32.53**	**BC**		
Varieties													
	0	26.70		27.62		26.99		27.97		25.62		26.98	ab
ESNovamis CL	24	20.06		24.55		29.33		28.20		25.90		25.61	b
	48	27.37		28.41		34.10		29.03		27.29		29.24	a
Mean		**24.71**		**26.86**		**30.14**		**28.40**		**26.27**		**27.28**	**c**
	0	34.68		36.92		32.34		35.65		34.76		34.87	a
LG 5542 CL	24	24.66		30.18		28.81		24.30		25.00		26.59	b
	48	29.17		29.33		31.71		27.44		24.09		28.35	b
Mean		**29.50**		**32.14**		**30.95**		**29.13**		**27.95**		**29.94**	**b**
	0	41.64		47.34		49.05		51.79		47.13		47.39	a
Oliva CL	24	30.68		33.84		41.19		35.79		32.74		34.85	b
	48	33.71		37.05		35.43		39.34		33.53		35.81	b
Mean		**35.35**		**39.41**		**41.89**		**42.31**		**37.80**		**39.35**	**a**
	0	42.72		49.79		49.57		51.37		45.60		47.81	a
ESGrafic CL	24	32.07		35.22		36.12		35.27		35.91		34.92	b
	48	29.44		31.91		31.48		33.24		32.82		31.78	b
Mean		**34.74**		**38.98**		**39.06**		**39.96**		**38.11**		**38.17**	**a**

The differences between values by different letters are significant. Capital letters for each row and small letters for each column.

$V_{LSD\ p<0.01}$	2.052	$K_{LSD\ p<0.01}$	1.777	$N_{LSD\ p<0.01}$	2.294
$VxK_{LSD\ p<0.01}$	3.555	VxN_{LSD}	ns	KxN_{LSD}	ns
$VxKxN_{LSD}$	ns				

V:Varieties K:Potassium Doses N: Nitrogen Doses ns : not significant

Table 6. Effects of Nitrogen and Potassium Doses on Calcium Uptake of Sunflower Varieties.
Çizelge 6. *Azot ve Potasyum Dozlarının Ayçiçeği Çeşitlerinin Kalsiyum Alımına Etkileri*

		Nitrogen Doses mg kg^{-1}											
		0		16		32		48		64		Mean	
Potassium Doses mg kg^{-1}	0	179.24		202.62		200.36		214.27		208.29		200.96	a
	24	153.73		185.10		196.35		185.89		172.56		178.72	b
	48	156.95		173.35		187.06		188.09		189.02		178.90	b
	Mean	**163.31**	**B**	**187.02**	**A**	**194.59**	**A**	**196.08**	**A**	**189.96**	**A**		
Varieties													
ESNovamis CL	0	232.49	A a	183.81	B a	194.98	AB a	211.79	AB a	210.97	AB a	206.81	a
	24	190.47	A ab	194.60	A a	190.15	A a	177.77	A a	160.02	A b	182.60	b
	48	165.41	B b	185.07	ABa	214.50	A a	214.11	A a	211.86	A a	198.19	ab
	Mean	**196.12**	**A a**	**187.83**	**A b**	**199.88**	**A ab**	**201.23**	**A a**	**194.29**	**A ab**	**195.87**	**a**
LG 5542 CL	0	166.79	B a	197.64	AB a	162.95	B b	204.50	AB a	213.10	A a	188.99	a
	24	154.82	A a	168.92	A a	159.26	A b	190.35	A a	169.72	A a	168.62	b
	48	138.35	B a	165.85	AB a	209.60	A a	186.34	A a	181.70	AB a	176.37	ab
	Mean	**153.32**	**B b**	**177.47**	**AB bc**	**177.27**	**AB b**	**193.73**	**A a**	**188.17**	**A ab**	**177.99**	**b**
Oliva CL	0	148.02	B ab	168.81	AB a	186.44	AB a	210.84	A a	193.92	A a	181.61	a
	24	125.76	Cb	143.97	BC a	196.59	A a	181.09	A ab	162.63	ABC a	162.01	a
	48	173.38	A a	163.91	A a	169.90	A a	156.52	A b	163.97	A a	165.54	a
	Mean	**149.05**	**B b**	**158.90**	**AB c**	**184.31**	**A b**	**182.81**	**A a**	**173.51**	**AB c**	**169.72**	**b**
ESGrafic CL	0	169.67	B a	260.22	A a	257.06	A a	229.96	A a	215.18	A a	226.42	a
	24	143.86	B a	232.91	A a	239.39	A a	194.33	A a	197.86	A a	201.67	b
	48	150.67	B a	178.57	AB b	154.24	AB b	195.41	AB a	198.56	A a	175.49	c
	Mean	**154.73**	**B b**	**223.90**	**A a**	**216.90**	**A a**	**206.57**	**A a**	**203.87**	**A a**	**201.19**	**a**

The differences between values by different letters are significant. Capital letters for each row and small letters for each column.

$V_{LSD\ p<0.01}$	15.459	$K_{LSD\ p<0.01}$	13.388	$N_{LSD\ p<0.01}$	17.284
$VxK_{LSD\ p<0.05}$	20.255	$VxN_{LSD\ P<0.05}$	26.149	KxN_{LSD}	ns
$VxKxN_{LSD\ P<0.05}$	45.292				

V:Varieties K:Potassium Doses N: Nitrogen Doses ns : not significant

Table 7. Effects of Nitrogen and Potassium Doses on Magnesium Uptake of Sunflower Varieties.
Çizelge 7. *Azot ve Potasyum Dozlarının Ayçiçeği Çeşitlerinin Magnezyum Alımına Etkileri*

		Nitrogen Doses mg kg^{-1}					
		0	16	32	48	64	Mean
Potassium Doses mg kg^{-1}	0	39.09 C a	45.00 B a	48.13 AB a	51.94 A a	50.71 A a	46.97 a
	24	32.73 C b	37.66 B b	42.32 A b	40.35 AB b	38.94 AB b	38.40 b
	48	34.66 B b	37.44 AB b	38.79 A b	39.22 A b	36.83 AB b	37.39 b
	Mean	**35.49 C**	**40.03 B**	**43.08 A**	**43.83 A**	**42.16 AB**	
Varieties							
ESNovamis CL	0	40.54	38.83	45.36	46.07	42.56	42.67 a
	24	35.18	35.58	37.91	37.57	34.63	36.17 b
	48	32.71	34.13	39.25	36.32	34.04	35.29 b
	Mean	**36.14 B ab**	**36.18 B b**	**40.84 A b**	**39.99 AB c**	**37.08 AB c**	**38.05 c**
LG 5542 CL	0	34.83	40.89	36.61	41.38	43.72	39.49 a
	24	28.84	34.65	33.31	32.54	31.80	32.23 b
	48	30.30	33.72	37.05	32.46	30.45	32.80 b
	Mean	**31.32 B c**	**36.42 A b**	**35.65 AB c**	**35.46 AB c**	**35.32 AB c**	**34.84 d**
Oliva CL	0	37.31	41.37	47.99	55.15	55.03	47.37 a
	24	30.33	33.32	43.89	40.13	38.73	37.28 b
	48	36.18	37.58	37.56	39.97	36.75	37.61 b
	Mean	**34.61 B bc**	**37.42 B b**	**43.15 A b**	**45.08 A b**	**43.51 A b**	**40.75 b**
ESGrafic CL	0	43.67	58.94	62.54	65.14	61.55	58.37 a
	24	36.55	47.07	54.17	51.16	50.59	47.91 b
	48	39.45	44.33	41.30	48.12	46.09	43.86 c
	Mean	**39.89 C a**	**50.11 B a**	**52.67 AB a**	**54.80 A a**	**52.74 AB a**	**50.04 a**

The differences between values by different letters are significant. Capital letters for each row and small letters for each column.

$V_{LSD\ p<0.01}$	2.084	$K_{LSD\ p<0.01}$	1.805	$N_{LSD\ p<0.01}$	17.284
$VxK_{LSD\ p<0.01}$	3.610	$VxN_{LSD\ P<0.01}$	4.660	$KxN_{LSD\ p<0.01}$	4.036
$VxKxN_{LSD}$	ns				

V:Varieties K:Potassium Doses N: Nitrogen Doses ns : not significant

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