Turk J
Field Crops
2018, 23(2), 195-205
DOI: 10.17557/tjfc.489858

THE EFFECTS OF NITROGEN DOSES APPLIED AT DIFFERENT GROWING PERIODS ON THE QUALITY AND YIELD OF OIL TYPE SUNFLOWER (*Helianthus annuus* L.) VARIETIES

*Kemalettin KARA**

Ataturk University, Faculty of Agriculture, Department of Field Crops, Erzurum, TURKEY
**Corresponding author:kara@atauni.edu.tr*

Received: 15.05.2018

ABSTRACT

This study was conducted at Erzurum in 2013 and 2014 to determine the effects of nitrogen fertilizer applied three different varieties oil type sunflower (*Helianthus annus* L.) at different developmental periods on quality and yield. Three sunflower types (Tarsan, L65400 and Imeria), three application times (stage of sowing, emergence and head formation) and four doses of nitrogen (0, 30, 60 and 90 kg ha^{-1}) was set up in three repetitions at the arrangement of "Split Plot". Oil and protein content and grain and oil yields were investigated in the study. While the effect of N application on oil and protein contents of the experimental years was not significant, its the effect on grain and oil yield was significant. Nitrogen fertilizers applied at the time of sowing had more effect on the other characters than the fertilizer application at the time of flowering and plate formation. The effect of nitrogen doses on all the characters studied was significant. The 30 kg nitrogen application and the rate of protein in 90 kg nitrogen application per ha^{-1} were higher than other doses of grain and oil. Except for the oil content, there was a significant difference between protein content and varieties for grain and oil yield. As a result of this study, it could be concluded that 60 kg of nitrogen applied at the time of sowing, 90 kg ha^{-1} of nitrogen dose, early and late sunflower varieties (Imeria and Tarsan) at the time of harvesting to obtained high the grains and oil content.

Keywords: Developmental stage, nitrogen fertilization, sunflower, yield, yield components

INTRODUCTION

Oils are essential nutrients and have an important place in human nutrition. Oils are provided from animal and vegetable sources. Demand for vegetable oils, which are inexpensive due to the limited and expensive oil of animal origin, has increased.

For vegetable oil production in Turkey, cotton, sunflower, peanut, sesame, soybean, flax, hemp, rapeseed, safflower and also olive cultivation is made. In the Eastern Anatolia Region, the most sunflower farming is made from oilseed plants. Cultural practices should be emphasized in order to get more yield from the unit area of the sunflower in the region. One of the cultural practices is fertilizing.

Sunflower removes too much plant nutrients from the soil compared to other cultivated plants so fertilization becomes more important. Fertilizers can be obtained in desired form and quality with the application in the form, quantity and time required by the plants.

One of the most important fertilizers for oil seed plants is nitrogenous fertilizers. Nitrogenous fertilizer seeds are important contributors in all the processes from throwing to the soil to maturing and harvesting. Excess nitrogen in sunflower farming accelerates vegetative growth in plants, causing the stems to become too dense and scarce, and thickening the seed husk causing the oil content in the seeds to decrease (Arıoglu, 2007).

In the studies carried out on the subject, Caliskan (1994) conducted a study on the application of 100 kg / ha nitrogen seeds which were taken constantly in all applications and in the other half when the plants were 15 cm in circulation, the maximum grain (3385,5 kg ha^{-1}) and oil yield (1297,4 kg ha^{-1}). Herdem (1999) stated that increased nitrogen dosages decreases the amount of oil, but in turn increases oil yield and protein content. Javier et al. (2002) determined that the doses of nitrogen were lower in the proportion of oil in the residual seed and that the effectiveness of the nitrogen doses varied according to the varieties. De Giorgio et al. (2007) in a study he conducted with different nitrogen doses in sunflower, found that seed, oil and protein production differed according to N doses and varieties. Maltas et al.(2018) indicated the effect of N on yield and large tuber formation.

The purpose of this study was to the effects of nitrogen fertilizer doses applied at different growth periods on the quality components and yield of varieties of oil type sunflower (*Helianthus annuus* L.) with different developmental periods.

MATERIALS AND METHODS

This research was carried out in 2013 and 2014 at the Ataturk University experimental farm. Tarsan (early), LG5400 (middle) and Imeria (latish) hybrid sunflower varieties and 21% ammonium sulphate and 45% triple super phosphate were used.

Climatical Conditions

The amount of precipitation from April to September was 151.4 mm in 2013, and 271.6 mm in 2014. The maximum rainfall was recorded in May (36.3 / 115.9 mm) and the lowest in August (7.8 / 4.8 mm) in both study years.

The average temperature was 14.4 ^{0} C in the first study and 15.7 ^{0}C in the second year while the highest temperature values in both study years were in August (19.5 and 22.2 ^{0} C). The lowest temperature values (7.2 and 7.7 ^{0} C) were in study years respectively.

The highest relative humidity was detected in April (64.4%) in the first study year, in May (64.8%) in the second study year, and in August (45.7% / 64.8%) in the first and second study years.

Soil properties

The pH of the soil was clayey-loamy, pH value was 7.77 to 7.80, organic matter was 1.10-0.77%, lime content was 2.15-7.84% and phosphorus content was 66,3-73,2 kg ha^{-1}.

Study Design

The experiment was in RCBD with in split plot arrangement with three replication.. Three oil type sunflower varieties (Tarsan, LG5400 and Imeria) used in the trial were divided into main parcels and so that 3 different application times (sowing, emergence and head formation time) and 4 different nitrogen doses (0, 30, 60 and 90 kg N / ha) was divided into sub plots. The determined amounts of nitrogenous fertilizers and 60 kg ha^{-1} phosphorous fertilizer were applied to the test area during sowing.

Each plot was 6 m in length, 3.5 m in width and consisted of 6 rows, the parcel area is 21.0 m^2. Sowing was made such that the distance between rows was 70 cm and the distance above rows was 25 cm. One plant from the beginning of parcels and one row each from side of parcels was discarded as side effect and 16 plants were harvested in each plot.

RESULTS AND DISCUSSION

Oil content (%)

The result of variance analysis are given in Table 1 and the means are given in Table 2.

According to the mean of the experimental factors, oil percentage was 46.3% in the first trial year and 39.8% in the second trial year (Table 2). Although there was a numerical difference in oil percentage between the trial years, there was no statistical difference (Table 1).

Table 1. Variance analysis results of oil and protein contents of sunflowers according to the average of the experimental factors

Variation Source	d.f	Oil content				d.f	Protein content			
		F values					F values			
		Years		Ave. Years			Years		Ave. Years	
		2013	2014	d.f	F values		2013	2014	d.f	F values
Yearl **(A)**	-	-	-	1	10,020	-	-	-	1	10,141
Error1	-			2		-			2	
Nitrogen doses **(B)**	3	0,740	2,080	3	1,794	3	0,857	2,622	3	1,989
A x B	-			3	0,068	-			3	0,511
Error2	6			12		6			12	
Applicatio time **(C)**	2	3,276*	0,302	2	1,550	2	0,428	1,329	2	1,371
AxC	-			2	1,273	-			2	0,360
BxC	6	1,252	0,266	6	0,225	6	3,543*	0,853	6	2,543*
AxBxC	-			6	1,111	-			6	1,929
Error3	16			32		16			32	
Variety **(D)**	2	2,207	2,201	2	2,784	2	1,162	5,299**	2	4,189*
A x D	-			2	1,624	-			2	0,024
B x D	6	0,193	1,073	6	0,687	6	1,566	1,612	6	1,149
A x B x D	-			6	0,501	-			6	2,005
CxD	4	1,377	1,242	4	1,820	4	1,544	1,475	4	1,568
AxCxD	-			4	0,811	-			4	1,489
BxCxD	12	0,993	1,206	12	1,236	12	0,713	1,777*	12	0,831
AxBxCxD	-			12	0,944	-			12	1,081
Error4	48			96		48			96	

** Marked F values are 1%, * marked F values are significant in 5% level.

Table 2. Mean oil and protein contents (%) of sunflower varieties depending on nitrogen doses applied during different development periods

Years	Nitrogen doses	Application time	Oil content			Average	Protein content			Average
			Varieties				Varieties			
			Tarsan	LG5400	İmeria		Tarsan	LG5400	İmeria	
2013	0	Planting	46,0	47,5	50,7	**46,9**	10,9	12,7	12,3	**12,7**
		Emergence	46,0	44,8	47,0		12,4	14,7	10,6	
		Head formation	49,2	44,4	46,8		13,4	14,1	12,8	
	3	Planting	48,8	42,2	47,9	**47,2**	12,4	12,4	12,3	**12,6**
		Emergence	46,0	48,5	47,6		13,9	11,1	11,8	
		Head formation	47,4	47,8	48,7		13,2	13,2	12,8	
	6	Planting	43,6	44,2	44,3	**45,9**	14,1	14,7	13,7	**13,6**
		Emergence	44,6	46,2	45,5		14,6	11,2	13,2	
		Head formation	47,7	46,4	50,4		14,6	12,9	13,7	
	9	Planting	44,0	44,7	45,1	**45,2**	13,5	14,2	14,9	**13,1**
		Emergence	43,4	46,2	44,0		14,5	13,5	12,9	
		Head formation	48,0	43,4	48,0		11,7	12,0	10,8	
	Variety average		**46,3**	**45,5**	**47,1**	**46,3**	**13,3**	**13,1**	**12,7**	**13,0**
	App. time	**Planting: 45,8 b Emer.: 45,8 b Head :47,4 a**				**App. time**	**Planting: 13,2 Eme:12,9 Head: 12,9**			
2014	0	Planting	37,0	39,8	40,1	**40,2**	10,5	10,5	9,7	**10,4**
		Emergence	42,5	39,2	39,7		11,0	9,9	11,9	
		Head formation	43,4	39,8	40,3		9,8	10,1	10,5	
	3	Planting	39,2	39,8	40,8	**40,5**	12,4	12,4	12,3	**12,6**
		Emergence	42,0	40,3	40,2		13,9	11,1	11,8	
		Head formation	42,0	40,4	39,2		13,2	13,2	12,8	
	6	Planting	40,4	36,8	41,7	**39,4**	14,1	14,7	13,7	**13,6**
		Emergence	38,8	38,8	40,5		14,6	11,2	13,2	
		Head formation	37,6	40,7	39,3		14,6	12,9	13,7	
	9	Planting	42,1	35,7	39,3	**39,1**	13,5	14,2	14,9	**13,1**
		Emergence	39,8	41,1	38,2		14,5	13,5	12,9	
		Head formation	42,1	36,9	36,5		11,7	12,0	10,8	
	Variety average		**40,6**	**39,1**	**39,7**	**39,8**	**12,8a**	**12,1b**	**12,4 a**	**12,4**
	App. time	**Planting: 39,4 Emer.: 40,1 Head: 39,8**				**App. time**	**Planting:11,1a Emer:10,8 ab Head:10,5 b**			
Years average	0	Planting	41,5	43,7	45,4	**43,6**	10,7	11,6	11,0	**11,6 b**
		Emergence	44,2	42,0	43,4		11,7	12,3	11,2	
		Head formation	46,3	41,9	43,6		11,6	12,1	11,7	
	3	Planting	44,0	41,0	44,4	**43,8**	12,3	11,6	11,2	**11,5 b**
		Emergence	44,0	44,4	43,9		12,1	11,1	10,9	
		Head formation	44,8	44,1	43,9		12,0	11,6	11,0	
	6	Planting	42,0	40,5	43,0	**42,6**	12,8	13,9	12,3	**12,3 a**
		Emergence	41,7	42,5	43,0		13,1	10,5	11,3	
		Head formation	42,6	43,5	44,9		12,6	11,6	12,4	
	9	Planting	43,1	40,2	42,2	**42,2**	12,5	13,1	12,9	**12,3 a**
		Emergence	41,6	43,7	41,1		13,2	12,7	11,9	
		Head formation	45,0	40,2	42,3		11,9	11,6	10,6	
	Variety average		**43,4**	**42,3**	**43,4**	**42.7**	**12,2a**	**12,0 ba**	**11,5b**	**11,9**
	App. time	**Planting: 42,6 Emer.: 43,0 Head: 43,6**				**App. time**	**Planting:12,5 Emer.:11,8 Head: 11,7**			

Means were significant at 1% level marked with capital letters. means were significant at 5% level marked with small letters.

The difference was not statistically significant (Table 1 and 2), although there was a numerical difference between the nitrogen doses both in the trial years and in the average of the years due to the oil content. Average of sunflower species to which 0, 30, 60, and 90 kg of nitrogen was applied per hectar ha^{-1} and application periods was 46,9, 47.2, 45.9 and 45.2% in the first trial year, 40.2, 40.5, 39.4 and 39.1% in the second trial period, and 43.6, 43.8, 42.6 and 42.1% (Table 2) as average of the years. In both years of the experiment and in the average of the years, there was a decrease in the oil content after 30 kg of nitrogen dose.

Several studies have reported that higher doses of nitrogen lower the rate of sunflower oil (Tripathi and Sawhney, 1992, Wagh et al., 1992, Herdem, 1999, Javier et al., 2002; Maltas et al., 2018).

The effect of fertilizer doses on the oil content of the sunflower for the growth periods was statistically significant at the level of 5% in the first trial year. Despite the numerical difference in the second year of the trial and the average of the years, there was no statistical difference (Table 1). In the first year of the experiment and in the average of the years, the doses of nitrogen increased the oil content as the application time lagged, while the second year of the experiment showed indecision (Table 2). Thus; In the first year of the experiment, in the oil contents were 45.8, 45.8 and 47.4%, respectively, in the first, second and third years, respectively, and 39.1, 40.1 and 39.8%, respectively, and 42.6, 43.0 and 43.6%).

There was no statistical difference among the varieties for oil percentage, in trial years, and in the average of years, even though there was a numerical difference (Tables 1 and 2). According to the average of the trial factors, the oil contents of Tarsan, L65400 and Imeria varieties were determined as 46.3, 45.5 and 47.1% respectively, 40.6, 39.1 and 47.18% in the second trial, 43.4, 42.3 and 43.4% in the average of the years. The presence of these differences among varieties can be attributed to both genetic characteristics and climate and cultural practices (Haris et al., 1978; Fick, 1978)

Protein content (%)

The percentage of grain protein was 13.0% in the first year and 12.4% in the second year (Table 2). Although there were numerical differences between years of trial, there was no statistical difference (Tables 1 and 2).

Non significant differences were found between the doses of nitrogen and the application times of these doses, both in the years of the trial and in the average of the years. Among the varieties of sunflower, 1% in the second trial year and 5% in the year average were found to be significant. No difference was found in the first trial year (Table 1).

The averages of each two years of trial and the average of the years of the experiment were close to each other and it was observed that protein averages increased as the average doses of nitrogen were increased. The highest protein content was determined at 60 kg ha^{-1} nitrogen dose (13.6%) in the first and second trial years and at least 30 kg / ha nitrogen dose (12.6%) in 2013 and controlapplication (10.4%) in 2014. At the average of the years, the highest protein content was determined in 60 and 90 kg ha^{-1} nitrogen application (12.3%) and least in 30 kg per hectera nitrogen application (11.5%).

Based on the results obtained, it was determined that the nitrogen dosing applications had an effect on the protein content in both trial years. Previous studies (Tripathi and Sawhney, 1992; Wagh et al., 1992), similar to the results of the study, have reported that nitrogen doses increase the percentage of residual protein.

In the first year of the experiment, the protein content was 13.2% during the sowing, 12.9% during the emergence period, 12.9% during the head formation period, 11.1%, 10.8 and 10.5% during the second trial period and 12.5, 11.8 and 11.7% in the average of years respectively. During the head formation period, the protein content was lower than in other application periods (Table 2).

The lowest percentage of protein was found in the Tarsan variety (12.3, 12.8 and 12.2%) in the two years and the average of the years, and the lowest protein content was found in the LG5400 (12.1%) in the second trial, 12.7 and 11.5 %).

In the first year of the experiment, the content of protein to nitrogen dose and fertilizer application time did not show a statistical significance at the level of 5% of the nitrogen dose x application time interactions (Table 1 and Figure 1).

According to the average of years, the non-stability of protein content in terms of nitrogen doses and fertilizer application times resulted in a statistically significant 5% level of nitrogen doses x application times interactions (Table 1 and Figure 2).

In the second year of the experiment, the protein content of varieties was not stable due to nitrogen doses and fertilizer application times, resulting in a significant increase in the doses of nitrogen doses x application times x type interaction as a statistical 5% level (Tables 1 and Figure 3).

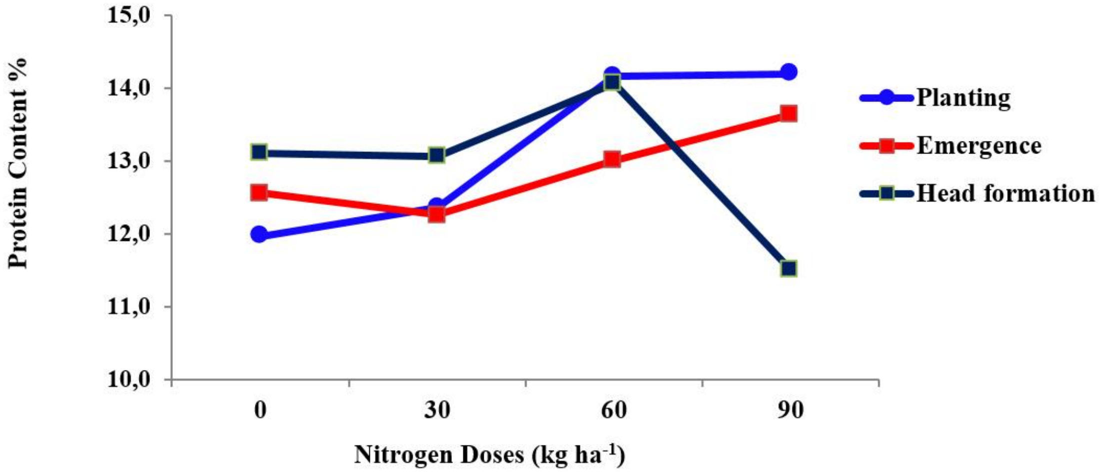

Figure 1. Nitrogen doses of protein contents x application times in the first year of the experiment.

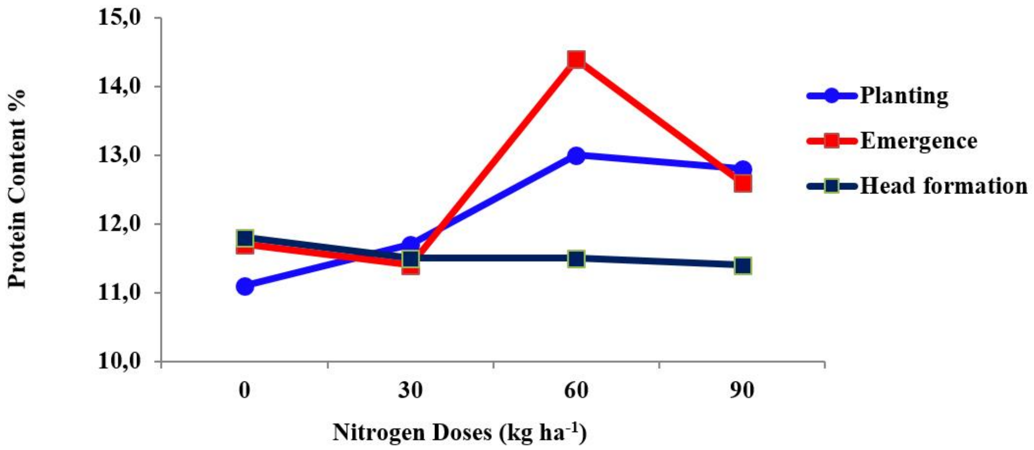

Figure 2. Nitrogen doses of protein contents according to averages of years x application times interactions

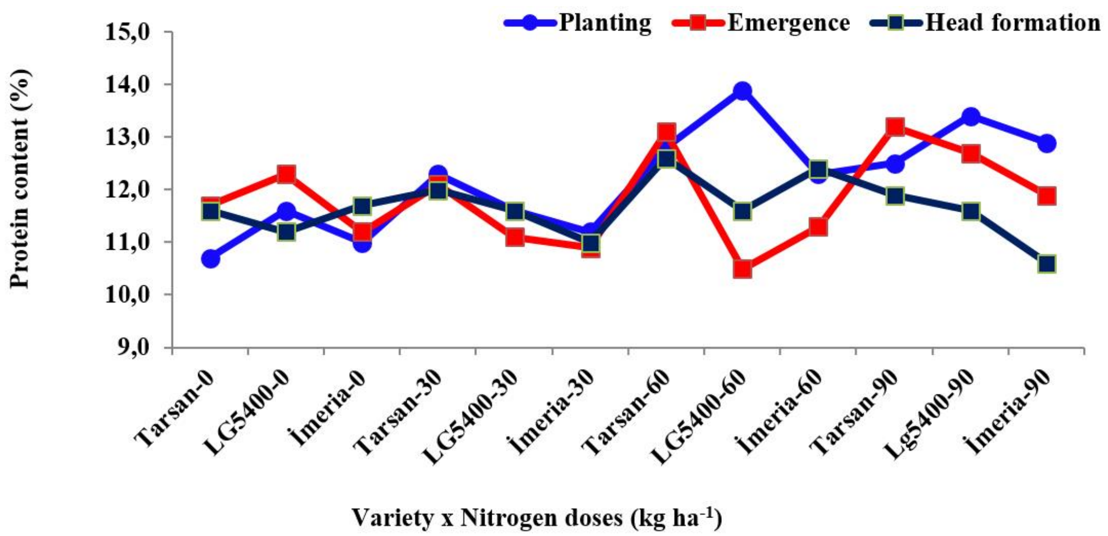

Figure 3. Nitrogen doses of protein contents in the second year of the experiment x application times x variety interactions

Grain yield (kg ha^{-1})

Grain yield in 2013 was (2968 kg ha^{-1}) 624.7 kg more than year 2014 (2343 kg ha^{-1}) and this difference between years is statistically significant at the 1% probability level (Tables 3 and 4). The yield of grain in the first trial is higher than that of the second trial in this year, because of the rainfall and temperature and the length of the growing period in this year.

Nitrogen doses were statistically significant at 5% level in the first year of application and at the average of years, whereas in the second year it was insignificant (Table 3). In the first year of the experiment and in the average of the years, as the nitrogen dose increased, the grain yield per decare increased. In the second trial, the increase in the nitrogen doses showed instability.

Table 3. Results of variance analysis of grain and oil yields of sunflower varieties depending on nitrogen doses applied during different development periods

Variation Source	**d.f**	**Grain yield**				**d.f**	**Oil yield**			
		F values					**F values**			
		Years		**Yıllar Ort.**			**Years**		**Yıllar Ort.**	
		2013	**2014**	**d.f**	**F values**		**2013**	**2014**	**d.f**	**F values**
Year **(A)**	-			1	43,97*	-			1	18,34*
Error₁	-			2		-			2	
Nitrogen doses (B)	3	3,745*	1,859	3	4,570*	3	1,283	2,147	3	1,400
A x B	-			3	1,337	-			3	1,594
Error₂	6			12		6			12	
Applicatio time (C)	2	3,191*	0,232	2	2,821*	2	1,263	0,140	2	1,210
AxC	-			2	1,268	-			2	0,764
BxC	6	4,004*	3,557*	6	2,793*	6	3,071*	3,495*	6	2,715*
AxBxC	-			6	4,869**	-			6	3,636**
Error₃	16			32		16			32	
Variety **(D)**	2	8,905**	1,102	2	3,325*	2	3,487*	0,968	2	2,357
A x D	-			2	7,283**	-			2	2,832
B x D	6	0,440	0,526	6	0,685	6	0,432	0,147	6	0,498
A x B x D	-			6	0,275	-			6	0,165
CxD	4	0,423	0,728	4	0,400	4	0,604	0,533	4	0,585
AxCxD	-			4	0,727	-			4	0,585
BxCxD	12	0,557	0,246	12	0,537	12	0,712	0,520	12	0,924
AxBxCxD	-			12	0,289	-			12	0,363
Error₄	48			96		48			96	

** Marked F values are 1%, * marked F values are significant in 5% level.

According to the applied nitrogen doses, the maximum yield of grain per decare per year in the experiment years and in the average of years was 3238, 2564 and 2901 kg ha^{-1}, respectively, at 90 kg nitrogen application while minimum yield was in first trial year and in average of years in control group as 2656 and 2468 kg and in second trial year as 2229 kg respectively at 60 kg nitrogen application per hectare. The results obtained from the experiment are in parallel with studies of Wagh et al. (1992), and Herdem (1999).

When the nitrogen doses were examined in terms of application times to sunflower, grain yield was found to be highest in the sowing period (3174 and 2379 kg ha^{-1}) and lowest in head formation period (2772, 2299 and 2545 kg ha^{-1}), respectively. In both years when the experiment was carried out and in the average of the years, the application of nitrogen applications together with sowing, resulted in the highest allowable yield.

This difference was statistically significant at the 1% level for the first year of experiment and at 5% level for the average of the years (Table 3). In the first year of the experiment and in the average of the years, the yield of Tarsan variety was 3241 and 2777 kg / ha^{-1}, respectively, and in the second year of experiment, the yield of the variety of Imeria (2438 kg ha^{-1}) was more than the other varieties.

In the first year of the experiment, the nitrogen yields and the stability of the fertilizer application times caused the nitrogen doses x to be significant at the 5% statistical level of the application time interactions (Table 3 and Figure 4).

In the second year of the experiment, the nitrogen yields and the stability of the fertilizer application times caused the nitrogen doses x to be significant at the 5% level of the application time interactions (Table 3 and Figure 5).

Nitrogen doses during non-fertilization trials and non-stabilization by application times resulted in a statistically significant 1% level for year x nitrogen doses x application times (Table 3 and Figure 6).

Table 4. Average values of grain and oil yields (kg ha^{-1}) of sunflower variaties depending on nitrogen doses applied during different growth periods.

Years	Nitrogen doses	Application time	Grain yield			Average	Oil yield			Average
			Varietes				Varietes			
			Tarsan	LG5400	İmeria		Tarsan	LG5400	İmeria	
2013	0	Planting	2392	2537	2349	2656c	1083	1159	1199	1245 b
		Emergence	2907	2466	1957		1345	1092	916	
		Head formation	3298	3113	2882		1620	1369	1421	
	3	Planting	3281	3109	2766	2901bc	1600	1296	1324	1356 ab
		Emergence	3260	3133	3080		1486	1514	1457	
		Head formation	2950	2601	1927		1368	1246	915	
	6	Planting	3855	3077	3319	3077ab	1685	1411	1466	1422 a
		Emergence	3206	2794	2594		1431	1310	1197	
		Head formation	3242	2844	2762		1553	1344	1399	
	9	Planting	4082	3501	3817		1655	1546	1605	1369 ab
		Emergence	3348	3434	3074	3237a	1362	1612	1380	
		Head formation	3070	2352	2460		1134	861	1164	
	Variety average		3241 A	2913 B	2749 B	2968	1444a	1313b	1287b	1348
	App. time	Planting: 3174 a Emer.:2938 ab Head.:2792b				App time	Planting:1419 a Emer:1342 ab head 1283 b			
2014	0	Planting	2282	2280	2262	2279	843	918	910	918
		Emergence	2345	2149	2589		996	820	1046	
		Head formation	2161	2131	2315		937	868	927	
	3	Planting	2685	2613	2649	2307	1050	1039	1087	933
		Emergence	1595	1875	1976		675	759	799	
		Head formation	2452	2458	2464		1032	995	962	
	6	Planting	2542	2226	1976	2229	1030	819	829	880
		Emergence	2173	2173	2522		856	857	1017	
		Head formation	2304	2018	2131		839	826	842	
	9	Planting	2327	2101	2607	2564	974	757	1008	1011
		Emergence	2679	3030	3178		1069	1249	1215	
		Head formation	2208	2363	2583		936	919	971	
	Variety average		2313	2285	2438	2345	936	902	968	935
	App. time	Planting: 2379 Emer.: 2357 Head.: 2299				App time	Plating: 939 Emer.:947 Head: 921			
Years average	0	Planting	2337	2408	2306	2467b	963	1039	1055	1082 b
		Emergence	2626	2308	2273		1171	956	981	
		Head formation	2729	2622	2599		1278	1119	1174	
	3	Planting	2983	2861	2707	2604b	1325	1168	1205	1145 ab
		Emergence	2428	2504	2528		1080	1137	1128	
		Head formation	2701	2530	2196		1200	1120	938	
	6	Planting	3198	2652	2648	2654b	1357	1115	1147	1151 ab
		Emergence	2689	2484	2558		1144	1084	1107	
		Head formation	2773	2431	2446		1196	1085	1121	
	9	Planting	3205	2801	3212	2901a	1314	1152	1307	1188 a
		Emergence	3013	3232	3126		1216	1430	1297	
		Head formation	2639	2358	2522		1035	890	1067	
	Variety average		2777a	2599b	2593b	2656	1190	1108	1127	114,2
	App. time	Planting: 2776 a Emer.: 2644 ab Head: 2545 b				App time	Planting:1179 Emer.:1144 Head:1102			

Means were significant at 1% level marked with capital letters. means were significant at 5% level marked with small letters.

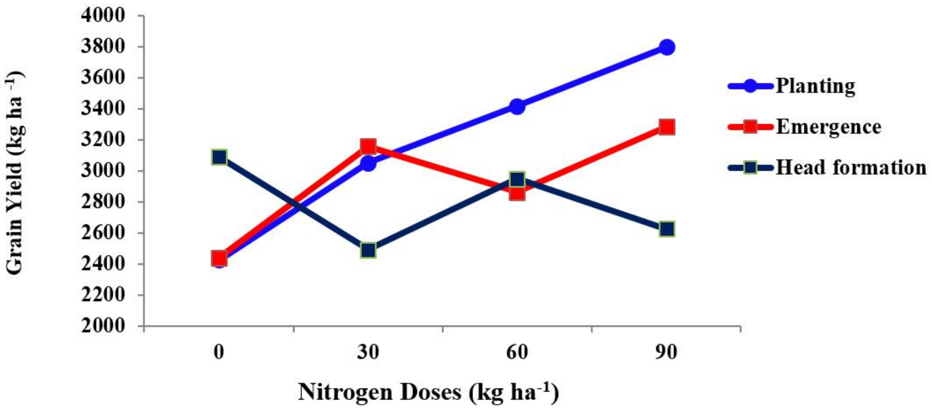

Figure 4. Nitrogen doses of grain yield x application times in the first year of the experiment.

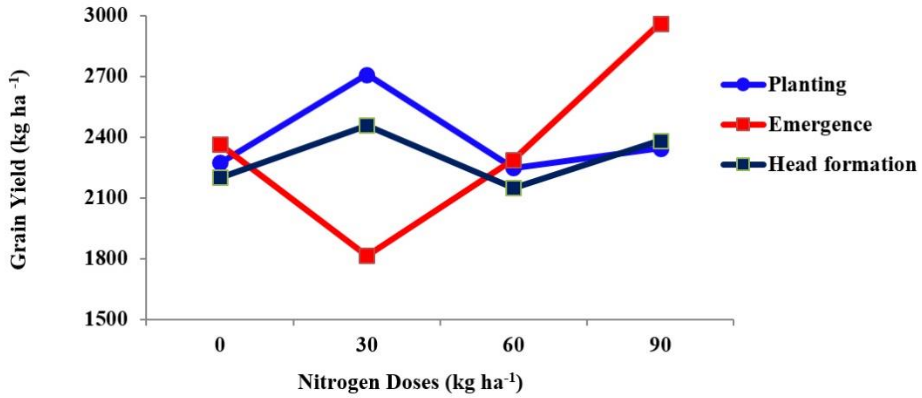

Figure 5. Nitrogen doses of grain yield x application times in the second year of the experiment.

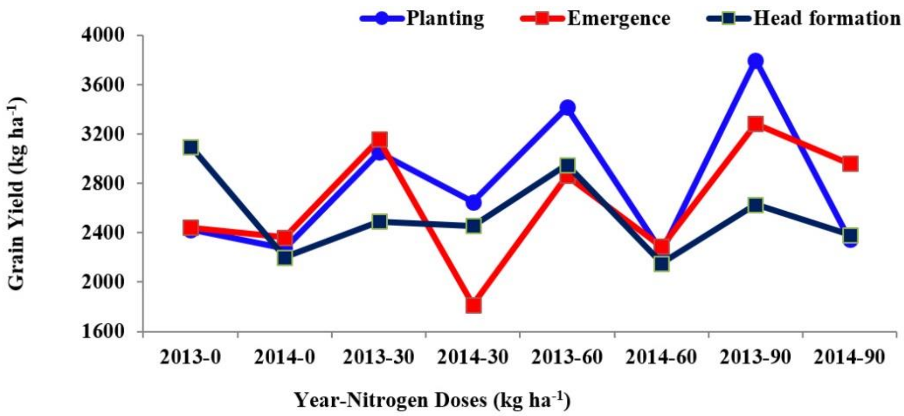

Figure 6. Year of grain yield x nitrogen dose x application time interactions

The fact that the grain yields of the varieties did not stabilize during the trial years led to the statistical significance of the year x variety of interactions at 5% level (Table 3 and Figure 7).

Oil yield (kg ha^{-1})

The difference between the years of experiment was in terms of the content of oil per decare, and this difference was statistically significant at the 5% probability level (Table 3). In the first year of the experiment, the oil yield per hectare was 1348 kg and in the second year it was 935 kg. The oil yield was higher in the first trial year than in the second trial year and this can be due to the fact that grain (2968 kg ha^{-1}) and oil content (46.3%) in this year was higher than the second year (2343 kg ha^{-1} and 39.8%) . (Table 3 and 4)

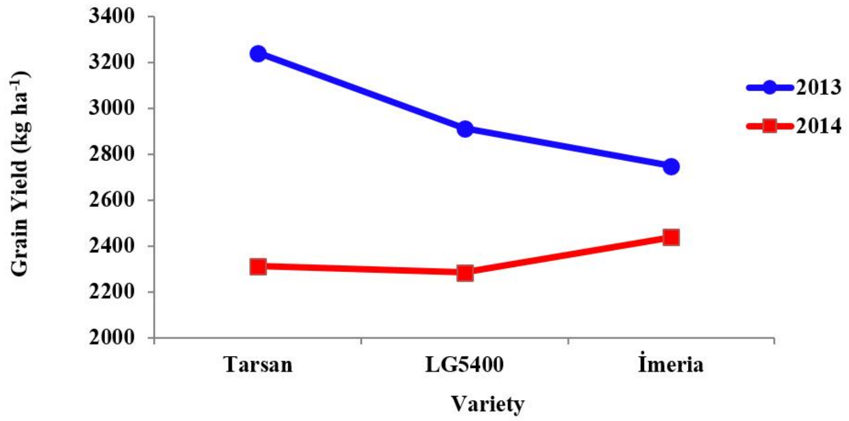

Figure 7. Variety of grain yield based to years x year interactions

There was no statistical difference between the doses of nitrogen in terms of oil yield, although there was a numerical difference between the two test years and the average of the years (Tables 4 and 3). The oil yields per decare obtained from the application of the 0, 30, 60 and 90 kg nitrogen doses were 1245, 1356, 1422 and 1369 kg ha^{-1} respectively in the first trial year, 918, 933, 880 and 1011 kg ha^{-1} in the second trial year, 1082, 1145, 1150 and 1188 kg ha^{-1} in the average of the years respectively (Table 4). In average of the years, it was observed that oil yield increased due to increasing nitrogen doses. When the averages of oil yields are examined, the results are similar to the studies performed by Herdem (1999), Esendal et al. (2010) who stated that obtained result showed increasing effect of nitrogen to oil yield.

Despite the numerical differences between the application times of nitrogen doses and the oil yields per hectar, both in the trial years and the averages of the years, no statistical differences were found (Tables 4 and 3). In the first year of the experiment oil yield per hectare in the sowing time was 1419 kg, 1342 kg in the emergence period and 1283 kg in the head formation period, 939, 947 and 921 kg in the second trial period and 1179 kg, 1144 and 1102 kg respectively in the average of years. During the test years and the average of the years, the oil yield per decare was lower than in the other application periods (Table 4).

There was no statistically significant difference in the second year of the test and in the average of the years, and in the first year there was a statistical difference in the level of 5% probability (Table 3). Tarsan, L65400 and Imeria varieties were determined as 1443, 1313 and 1287 kg in the first year of the test of the oil yield per hectare, 936, 902 and 968 kg in the second trial period, and 1190, 1108 and 1127 kg in the average of the years. In the first trial year of the Tarsan variety, the average oil yield (1443 and 1190 kg ha^{-1}) was higher than the other varieties in the first trial period and in the average of the years.

The fact that oil yield demonstrating non-uniformity in the first and second years of the experiment and the average of the years in terms of nitrogen doses and fertilizer application time, caused “nitrogen doses x application times” interaction to be in a statistically significant at 5% level (Table 3 and Figures 8, 9 and 10).

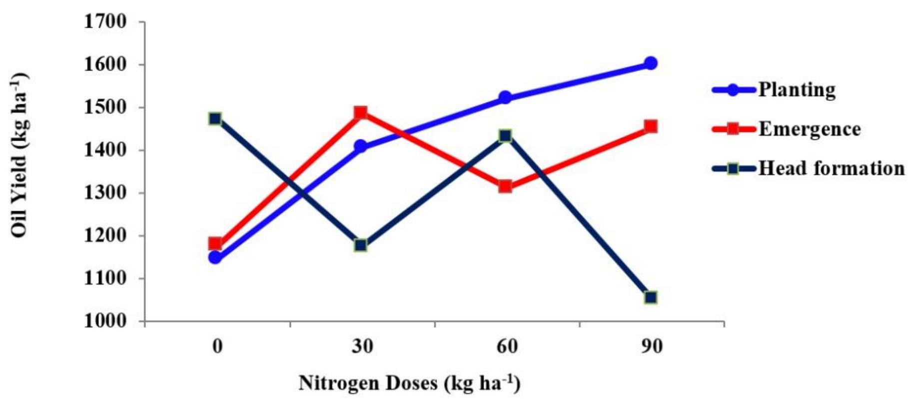

Figure 8. Nitrogen doses of oil yield x application times in the first year of the experiment

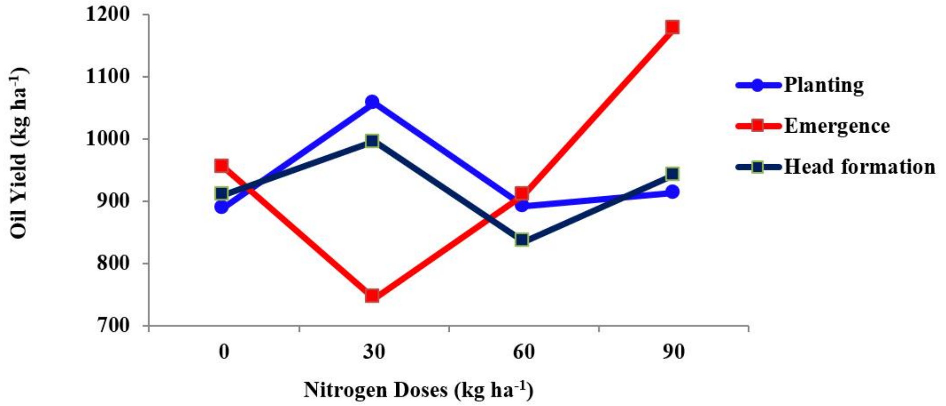

Figure 9. Nitrogen doses of oil yield x application times in the second year of the experiment

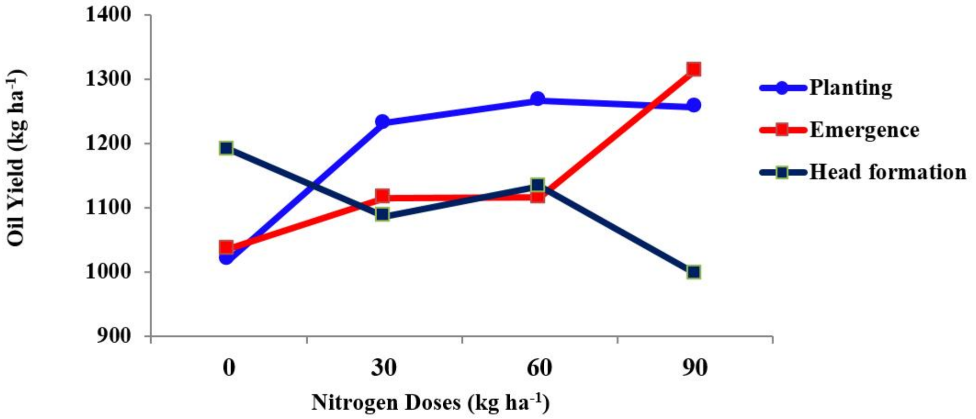

Figure 10. Nitrogen doses of oil yields based to years x application times interactions

Nitrogen doses during the trial years and the fact that the oil yields were not determined according to the application times caused "year x nitrogen doses x application times" interaction to be in a statistically significant 1% level (Table 3 and Figure 11).

This study was carried out in order to determine the effects on the quality and yield of nitrogenous fertilizer doses applied in different development periods of oil sunflower varieties with different development periods.

There was no effect on the oil and protein contents of the trial years, and it had an effect on grain and oil yield.

The effect of nitrogen doses on oil and protein content was not significant. The content of oil in 30 kg ha^{-1} nitrogen application (47.2, 40.5 and 43.8%) and protein content in 60 kg ha^{-1} nitrogen application (13.6, 13.6 and 12.3%) were the most. In the second trial, the maximum yield was 90 kg ha^{-1} nitrogen (3237, 2564 and 2901 kg ha^{-1}), the oil yield was 60 kg nitrogen (1422 kg ha^{-1}) in the first trial year, and (1011 and 1180 kg ha^{-1}) in second trial year and average of the years, at a nitrogen dosage of 90 kg ha^{-1} respectively.

The content of oil (45.8, 40.1 and 43.0%) and protein (13.2, 11.1 and 12.0%) were higher in the application of nitrogen doses at the time of emergence, and in the application at sowing period the grain and oil yield were (3174, 2379 and 2776 kg ha^{-1}) and (1419, 939 and 1179 kg ha^{-1}) respectively and these values were higher than in other application periods.

There were differences in the characters examined among the varieties. The grain yield was (3240, 2313 and 2777 kg ha^{-1}) and oil yield was (1444, 936 and 1190 kg ha^{-1}) for Tarsan variety, while the oil contents were (47.1, 39.7 and 43.4%) for Imeria variety and (46.3, 40.1 and 43.3%) for Tarsan variety. Besides, the protein content of Tarsan variety (13.3, 12.8 and 12.2%) was higher than the other varieties.

As a result, when considering the grain and oil yield in the study, 90 kg of nitrogen dose per hectare should be applied during emergence period to species with median development period (LG 5400), while 60 kg nitrogen dose should be applied to early and late sunflower varieties (İmeria and Tarsan), during sowing period.

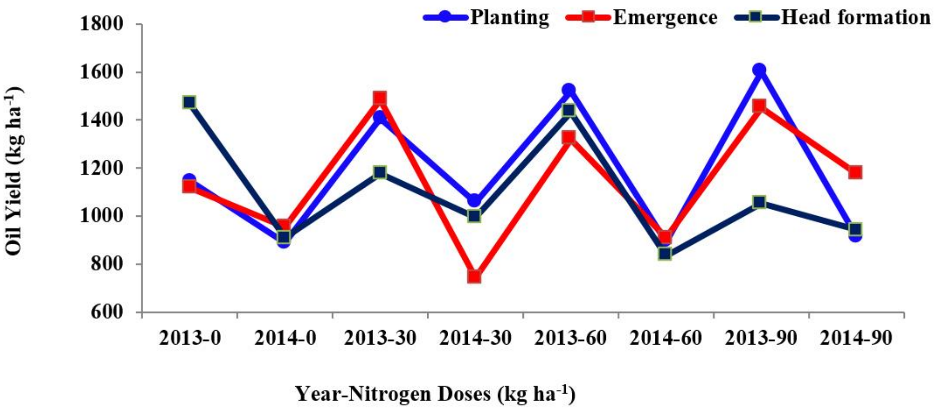

Figure 11. Nitrogen doses of oil yields based to years x application times interactions

LITERATURE CITED

Arıoglu, H.H. 2007. Breeding and Breeding of Oil Plants. CU Agricultural Faculty General Publication No: 220 Course Books Publication No: A-70, pp, 160-290.

Butcher, Y. 1997. Effects of different nitrogen levels on yield and quality in sunflower (*Helianthus annuus* L.). Harran University Journal of Agricultural Faculty. 1(2): 29-38.

Calıskan, O. 1994. The Effect of Nitrogen Based Fertilizer Applied in Various Vegetation Periods on Yield and Important Agricultural Characteristics of Sunflower (*Helianthus annuus* L.). Ondokuz Mayis University Institute of Science. Master Thesis, 54pp.

De Giorgio, D., V. Montemurro and F. Fornaro. 2007. Four-year field experiment on nitrogen application to sunflower genotypes grown in semiarid conditions. Helia. 30 (47):15-26.

Esendal, E., C. Pasa, V. Pekcan and M.I. Yilmaz. 2010. Effect of Different Doss of Nitrogen on the Yield and Yield Components of Sunflower (*Helianthus annus* L.). 8th European Sunflower Biotechology Conference, 1-3 March 2010, Antalya, Turkey. P:81

Fick, G. N. 1978. Sunflower Science and Technology: Breeding and Genetics. In: Carter JF (ed) Sunflower science and technology. ASA, CSSA and SSSA, Madison, pp 279-327

Harris, H.C., J.R. McWilliam and W.K. Mason. 1978. Inflorescence of temperature on oil content and composition of sunflower seed. Australian Journal of Agricultural Research. 29: 203-212.

Herdem, E. 1999. Effect of nitrogen (N) doses on yield and yield components in some sunflower (*Helianthus annuus* L.) varieties. Trakya University Institute of Science and Technology. Higher Language Thesis, 45pp.

Javier, D., F. Scheiner, H. Guitiérrez-Boem and R.S. Lavado. 2002. Sunflower nitrogen requirement and 15 N fertilizer recovery in Western Pampas, Argentina. European Journal of Agronomy. 17: 73-79.

Maltas, A., B.Dupuis and S. Sinaj. 2018. Yield and quality response of two potato cultivars to nitrogen fertilization. Potato Reseach. 61: 97-114.

Star, T. 2014. Determination of the effect of different doses of nitrogen on the yield and yield components of sunflower (*Helianthus annuus* L.) varieties. Iğdır University Graduate School of Natural and Applied Sciences Field Crops Department. Master Thesis, 63pp.

Tripathi, H.P and J.S. Sawhney. 1992. Nutrient uptake and quality of sunflower as influenced by irrigation and nitrogen levels. F. Crop abst. 45 (5): 3240.

Wagh, R.G., S.S. Babar and S.T. Thoarat. 1992. Effects of sowing time and nitrogen levels on yield and yield attributes of kharif sunflower. Field Crop Abst. 46 (12): 557.