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INTERACTIVE EFFECTS OF DIFFERENT INTRA-ROW SPACING AND NITROGEN LEVELS ON YIELD AND YIELD COMPONENTS OF CONFECTIONERY SUNFLOWER (*HELIANTHUS ANNUUS* L.) GENOTYPE (ALACA) UNDER ANKARA CONDITIONS

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ABSTRACT

The aim of the research was to determine the effects of different intra-row spacing (20, 30 and 40 cm) and nitrogen levels (0, 40, 80 and 120 kg ha^{-1}) on yield and yield components of confectionery sunflower genotype (Alaca). The experiment was laid on "Randomized Complete Block Design" as split plots with three replications. The highest seed yield obtained from 20 cm intra-row spacing and 120 kg ha^{-1} nitrogen and the score were 243.3 kg da^{-1} and 315.3 kg da^{-1} in 2007 and 2008. Nitrogen level increased the 1000 seed weight. In the year with irregular rainfall (2007) in the vegetation stage the highest 1000 seed weight score was obtained as 129.6 g in 40 kg ha^{-1} nitrogen treatment whereas in the year with normal rainfall distribution the highest 1000 seed weight score was obtained as 113.4 in 80 kg ha^{-1} nitrogen. Results revealed that; decreasing intra-row spacing led to decrease in seed yield per head but increase of the seed yield. However, increasing plant population caused to small seeds and this feature is not required for confectionery varieties. For this reason, 30 cm intra-row spacing and 80 kg ha^{-1} nitrogen is appropriate for Alaca genotype.

INTRODUCTION

Confectionery sunflower is one of the most common crop cultivated in Central Anatolia that has a larger head size compared to oilseed sunflower. The total cultivation area of confectionery sunflower is 104.992 ha in Turkey and 35.783 ha of this cultivation area is in Central Anatolia. It is an important cash crop due to its used for birdfeed and human consumption. The impact of plant density and nitrogen supply on sunflower yield and yield component have been studied previously with the aim to determine appropriate plant population and nitrogen levels for sunflower production (Zubriski and Zimmerman 1974, Kıllı 2004). Several researchers observed that plant spacing has an importance to enhance the yield of sunflower (Robinson *et al.,* 1980; Redy *et al.,* 1997, Jahangir *et al.,* 2006). Nitrogen one of the limiting factor in sunflower growth play an important role on yield (Montemurro and De Giorgio 2005). Inadequate nitrogen supply in the soil has a negative impact on vegetative and generative growth and induces premature senescence which leads yield loss (Narwal and Malik 1985; Khokani *et al.,* 1993; Legha and Giri 1999; Tomar *et al.,* 1999).

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Contrarily, high nitrogen supply may delay crop maturity and reduce seed yield (Farah *et al.,* 1981, Hocking *et al.,* 1987, Özer *et al.,* 2004). Also over fertilization with nitrogen is one of the main contamination reason of groundwater with nitrates (Magdoff *et al.,* 1997; Strong, 1995, Scheiner *et al.,* 2002). It is important to adjust nitrogen for different varieties and species to avoid excessive nitrogen fertilization. In Central Anatolia, confectionery sunflower is grown under irrigated or rainfed conditions. Confectionery sunflower yield (83 kg da^{-1}) under rainfed condition is very low (Day and Kolsarıcı, 2014) compare to average yield (109 kg da^{-1}) of confectionery sunflower under irrigated conditions.

However agro-techniques used in the region under irrigated conditions are comparatively poor. Plant density and proper fertilizer application to soil are necessary for optimum yield of crops. There is very limited information on confectionery sunflower (*Helianthus annuus* L.) response to different intra-row spacing and N in comparison to oil type sunflower. However, there is no published data available on plant population and N rate response on yield of confectionery sunflower in Central Anatolian region. Keeping in view, the present study was designed with objectives to investigate the role of different intra-row spacing and N levels on yield and yield components of confectionery sunflower genotype Alaca.

MATERIALS AND METHODS

The experiment was carried out at the experimental field of Department of Field Crops, Faculty of Agriculture, University of Ankara in 2007 and 2008, in Turkey. Long term average precipitation for this area was 337.6 mm. The field soil in the experiment was clay loam (25% sand, 40% clay, 35% silt), alkaline, low in organic matter, moderately calcareous (Table 2). Confectionery sunflower seeds of Alaca genotype were procured from Trakya Agricultural Research Institute. Three intra-row spacing (R) (R_1=20, R_2=30 and R_3=40 cm) and four different levels of nitrogen (N) (0 (N_0), 40 (N_1), 80 (N_2) and 120 kg ha^{-1} (N_3.)) were used in field experiment. N was applied at two different stages in equal amount by using Ammonium sulfate. First application of N was made at the time of land preparation and second was applied to soil at the R-1growth stage of (The terminal bud forms a miniature floral head rather than a cluster of leaves) described by Schneiter and Miller (1981). The planting was done manually in both 2007 and 2008. The experiment was laid on randomized complete block design as split plots with three replicates. An individual plot size were 21.84 m^2 (5.2 × 4.2 m). At the harvest time, 10 plants were selected at random from each plot. Plant height, head diameter, 1000 seed weight, harvest index, hull ratio, seed yield per plant, protein content, oil content and seed yield per decare of confectionery sunflower genotype Alaca was measured and recorded. 1000 seed weight calculated according to ISTA (8 replications of 100 weighed separately, calculated average weight of 100 seeds and multiplied by 10).

Protein content was determined with kjeldahl method (Akyıldız 1968), Oil content determination was done with hexane extraction (Akyıldız 1968). Harvest index was calculated by using this equation HI=Ye/Yb.100 (Gholinezhad *et al.,* 2009).

HI = Harvest index
Ye = Economical yield
Yb = Biological yield

Data pertaining plant height and different yield contributing characters were analyzed using statistical analysis by MSTAT-C and Duncan's Multiple Range Test was used for post hoc tests. All data transformed into percentages were subjected to arcsine transformation (Snedecor and Cocharan, 1967).

RESULTS AND DISCUSSION

In this study, plant height, head diameter, 1000 seed weight, harvest index, hull ratio, seed yield per plant, protein ratio, oil ratio and seed yield per decare of confectionery sunflower genotype Alaca was investigated under different intra-row spacing and N doses. The data of the 2-year experiment was subjected to statistical analysis. The average precipitation for 2008 (323.2 mm) was higher than that observed in 2007 (305.2 mm). Interestingly, rainfall in May of 2007 (17.9 mm) was below than the 2008 and was least for the last 50 years (Table 1).

Plant Height

Results on plant height clearly showed the non significant effects of intra-row spacing. Average plant height of two years ranged from 153.5 to 162.1 cm. However significant effects of N doses were observed. Average plant height of two years ranged from 148.4 to 163.6 cm with maximum plant height obtained from N1. Further levels of N resulted in slight decline in plant height but that was non significant. Results further revealed that increase in plant height during 2008 compared to 2007 irrespective of row spacing and N doses. Moreover, interactive effect of R × N on plant height was non significant. Average plant height for two years ranged from 144.0 to 168.5 cm. The increase in plant height due to the N application was also reported by Tahir (1996), Ali *et al.,* (2004) and Özer *et al.,* (2004).

Head Diameter

Head diameter is one of the major yield components in sunflower and the size of confectionery type sunflower is of immense importance. Results clearly indicated that impact of intra-row spacing was non significant with the scores ranged

Table 1. Average precipitaition, temperature and relative humidity of the 2007 and 2008

Months	Precipitation(mm)			Temperature (°C)			Relative Humidity (%)		
	Long term average	2007	2008	Long term average	2007	2008	Long term average	2007	2008
January	33.1	39.0	20.1	0.7	1.2	-4.0	76.5	76.0	76.3
February	38.1	16.4	6.5	0.7	2.5	0.1	73.1	68.5	68.9
March	24.5	37.5	54.9	6.4	7.2	10.1	63.0	59.5	57.6
April	39.8	23.8	32.7	12.6	9.1	13.7	57.8	53.7	54.8
May	47.9	17.9	45.4	16.1	20.4	15.5	56.6	41.1	50.9
June	20.5	31.7	10.3	20.1	22.6	22.0	50.5	45.0	41.0
July	8.8	3.9	0.0	23.5	26.7	24.9	45.9	29.8	35.7
August	6.3	9.8	0.7	23.4	26.3	26.6	46.5	37.1	34.5
September	6.8	0	61.6	20.4	20.9	19.9	46.4	35.0	50.3
October	29.0	14.1	18.6	14.9	16.7	13.3	59.1	49.4	63.8
November	49.6	66.7	43.6	5.7	6.7	8.7	72.1	66.6	72.1
December	33.2	44.4	28.8	0.9	2.0	2.0	78.0	75.7	78.6
Tot./Ave.	337.6	305.2	323.2	12.2	13.5	12.7	60.3	53.1	57.0

*Turkish State Meteorological Service. Ankara 2009.

Table 2. Physical and chemical characteristics of soil where the experiment was conducted

Years	Depth (cm)	Soil Texture	Saturation (%)	Salinity (%)	pH	$CaCO_3$ (%)	Available P_2O_5 (kg da^{-1})	Available K_2O (kg da^{-1})	Total N (%)	Organic Compound (%)
2007	0-20	Clay-loam	50	0.085	8.07	10.34	8.65	245	0.08	1.01
	20-40	Clay-loam	53	0.087	8.04	8.31	11.02	190	0.17	1.14
2008	0-20	Clay-loam	54	0.084	7.85	9.00	7.85	160	0.06	1.25
	20-40	Clay-loam	60	0.088	8.00	10.00	6.45	125	0.15	1.02

Table 3. Summary of the analysis of variance for several variables of confectionery sunflower genotype grown under different intra-row spacing and N doses

	Plant Height	Head diameter	1000 seed weight	Harvest Index	Hull ratio	Seed yield per plant	Seed Protein ratio	Seed Oil ratio	Seed yield
Year	**		**		**	**		**	**
R					*	*		*	**
N	**		**	**		**		**	**
R×N					*			**	
R×Y						*			**
N×Y						*	*	**	*
R×N×Y		*							**

*, **: Significant at the 0.05, 0.01level. (R: Intra row spacing, N: Nitrogen doses, Y: Year)

Table 4. Impact of different intra-row spacing and N doses on plant height, head diameter and 1000 seed weight of the confectionery sunflower

Intra-row Spacing (R)	Plant height (cm)			Head diameter (cm)			1000 seed weight (g)		
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
R1	141.8	165.3	153.5	18.6	18.3	18.4	122.8	98.7	110.8
R2	150.4	173.9	162.1	20.2	19.0	19.6	128.7	110.4	119.5
R3	144.7	174.6	159.6	19.2	19.9	19.2	124.5	107.2	115.8
N doses									
N0	135.7	161.2	148.4b**	20.7	19.4	20.1	114.8	90.4	102.6b**
N1	147.8	179.3	163.6a	19.1	18.8	18.5	129.6	105.9	117.7a
N2	151.4	171.2	161.3a	18.9	18.7	18.8	128.5	113.4	121.0a
N3	147.7	173.2	160.0a	18.6	19.3	18.9	128.3	112.0	120.2a
Years	145.4b	171.3a**	158.4	19.1	19.0	19.1	125.3a	105.4b**	115.4
R × N									
R1 × N0	137.3	150.7	144.0	20.6a	19.0a-c*	19.8	115.0	81.7	98.4
R1 × N1	144.3	165.3	154.8	20.1ab	16.8b-d	18.5	127.3	100.0	113.7
R1 × N2	141.7	167.3	154.5	18.3a-d	18.5a-d	18.4	126.0	113.3	119.7
R1 × N3	143.7	177.7	160.7	15.5cd	18.8a-d	17.1	122.7	100.0	111.3
R2 × N0	138.7	163.0	150.8	20.9a	19.1a-c	20.0	117.7	95.3	106.5
R2 × N1	149.0	188.0	168.5	19.3ab	19.8ab	19.6	133.7	115.7	124.7
R2 x N2	156.7	174.7	165.7	18.9a-c	18.6a-d	18.7	136.3	114.7	125.5
R2 × N3	157.3	170.0	162.3	21.5a	18.5a-d	20.0	127.0	116.0	121.5
R3 × N0	131.0	170.0	150.5	20.6a	20.2ab	20.4	111.7	94.3	103.0
R3 × N1	150.0	184.7	167.3	15.2d	19.8ab	17.5	127.7	102.0	114.8
R3 × N2	155.7	171.7	163.7	19.5ab	18.9a-c	19.2	123.3	112.3	117.8
R3 × N3	142.0	172.0	157.0	18.5a-d	20.5ab	19.5	135.3	120.0	127.7

*, **: Significant at the 0.05, 0.01 level. There were no significant differences between the mean values shown with the same letters in 0.05 and 0.01 level. R1: 20 cm, R2: 30 cm, R3: 40 cm; N0: 0 kg N da^{-1}, N1: 4 kg N da^{-1}, N2: 8 kg N da^{-1}, N3: 12 kg N da^{-1}

Table 5. Impact of different intra-row spacing and N doses on harvest index, hull ratio and seed yield per head of the confectionery sunflower

Intra-row Spacing (R)	Harvest index (%)			Hull ratio (%)			Seed yield per plant (g $plant^{-1}$)		
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
R1	39.8	39.3	39.5	47.9	43.1	45.5b**	80.2bc	89.6b*	84.9b*
R2	39.5	39.3	39.4	44.7	44.3	44.5b	73.6c	108.8a	91.2ab
R3	39.1	39.9	39.5	48.9	45.8	47.3a	85.3bc	113.0a	99.1a
N doses									
N0	37.1	35.3	36.2c**	48.2	46.3	47.2	70.8d	89.5bc*	80.1b**
N1	37.3	37.2	37.3c	46.1	44.4	45.3	79.7cd	109.0a	94.3a
N2	39.8	40.7	40.2b	46.3	44.3	45.3	92.2b	106.9a	99.6a
N3	43.7	44.9	44.3a	48.1	42.5	45.3	76.0d	109.8a	92.9a
Years	39.5	39.5	39.5	47.2a	44.4b**	45.8	79.2b	103.8a**	91.5
R × N									
R1 × N0	34.1	34.0	34.1	50.0	46.7	48.4ab*	69.3	68.0	68.7
R1 × N1	36.7	36.2	36.5	45.1	40.5	42.8d	79.3	86.0	82.7
R1 × N2	41.9	41.2	41.6	45.2	43.0	44.1b-d	99.0	95.3	97.2
R1 × N3	46.4	45.8	46.1	51.5	42.2	46.9a-c	73.0	109.0	91.0
R2 × N0	38.0	34.5	36.2	46.4	45.9	46.2a-d	68.7	97.7	83.2
R2 × N1	37.7	37.8	37.8	45.0	42.6	43.8cd	73.7	120.3	97.0
R2 × N2	40.3	40.5	40.4	44.3	44.7	44.5b-d	78.3	113.7	96.0
R2 × N3	41.9	44.3	43.1	43.2	44.0	43.6cd	73.7	103.3	88.5
R3 × N0	39.1	37.3	38.2	48.1	46.4	47.3a-c	74.3	102.7	88.5
R3 × N1	37.4	37.7	37.6	48.2	50.2	49.2a	86.0	120.7	103.3
R3 × N2	37.1	40.4	38.7	49.6	45.2	47.4a-c	99.3	111.7	105.5
R3 × N3	42.8	44.5	43.7	49.6	41.4	45.5a-d	81.3	117.0	99.2

*, **: Significant at the 0.05, 0.01 level. There were no significant differences between the mean values shown with the same letters in 0.05 and 0.01 level. R1: 20 cm, R2: 30 cm, R3: 40 cm; N_0: 0 kg N da^{-1}, N_1: 4 kg N da^{-1}, N_2: 8 kg N da^{-1}, N_3: 12 kg N da^{-1}

Table 6. Impact of different intra-row spacing and N doses on protein ratio, oil ratio and seed yield of the confectionery sunflower

Intra-row Spacing (R)	Protein ratio (%)			Oil ratio (%)			Seed yield (kg da^{-1})		
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
R1	28.6	28.0	28.3	43.7	48.4	46.0a*	224.9b	301.0a**	263.0a**
R2	30.8	29.2	30.0	43.2	46.6	44.9ab	198.6cd	234.0b	216.3b
R3	29.2	28.6	28.9	40.6	46.2	43.4b	190.0d	207.2c	198.6c
N doses									
N0	30.3	28.7	29.5a*	39.7d	42.0cd**	40.9c**	187.2e	218.2d*	202.7d**
N1	30.6	28.4	29.5a	40.7cd	48.4ab	44.6b	197.1e	245.1c	221.1c
N2	28.0	27.8	27.9b	43.0c	49.8a	46.4ab	214.7d	257.2b	235.9b
N3	29.2	29.5	29.4a	46.6b	48.1ab	47.4a	219.0d	269.0a	244.0a
Years	29.5	28.6	29.1	42.5b	47.1a**	44.8	204.5b	247.4a**	226.0
R × N									
R1 × N0	31.0a-c	27.5d-g*	29.3	41.9	44.5	43.2cd**	202.3f-h	274.7b**	238.5
R1 × N1	29.6a-g	27.5c-g	28.6	43.3	52.6	48.0ab	212.3e-g	313.3a	262.8
R1 × N2	27.0e-g	28.6b-g	27.8	42.9	51.1	47.0a-c	241.7cd	300.7a	271.2
R1 × N3	26.6fg	28.4b-g	27.5	46.7	45.4	46.1a-c	243.3cd	315.3a	279.3
R1 × N0	29.8a-g	29.3a-g	29.6	41.2	38.4	39.8d	182.0ij	215.3ef	198.7
R2 × N1	32.3a	28.0b-g	30.2	41.2	48.6	44.9a-c	194.7g-i	229.0de	211.8
R2 × N2	30.5a-d	27.9c-g	29.2	44.8	50.3	47.6ab	205.7fg	242.7cd	224.2
R2 × N3	30.7a-d	31.7ab	31.2	45.6	49.1	47.4ab	212.0e-g	249.0c	230.5
R3 × N0	30.1a-e	29.2a-g	29.7	36.1	43.2	39.7d	177.3ij	164.7j	171.0
R3 × N1	29.8a-f	29.8a-g	29.8	37.5	44.1	40.8d	184.3hi	193.0g-i	188.7
R3 × N2	26.4g	26.8e-g	26.6	41.2	47.9	44.6bc	196.7f-i	228.3de	212.5
R3 × N3	30.3a-e	28.5b-g	29.4	47.5	49.7	48.6a	201.7f-h	242.7cd	222.2

*, **:Significant at the 0.05, 0.01 level. There were no significant differences between the mean values shown with the same letters in 0.05 and 0.01 level. R1: 20 cm, R2: 30 cm, R3: 40 cm; N_0: 0 kg N da^{-1}, N_1: 4 kg N da^{-1}, N_2: 8 kg N da^{-1}, N_3: 12 kg N da^{-1}

from 18.4 cm to 19.6 cm. Impact of N levels on head diameter was also non-significant and average head diameter of two years ranged from 18.5 cm to 20.1 cm. Response of head diameter R × N was non-significant and the average of two year differed between 17.1 cm and 20.4 cm. Apart from our results Kıllı (2004) determined that the lowest plant density resulted in increase of head diameter and significantly increase in head diameter with the high level of N. Robinson *et al.,* (1985) also stated that head diameter significantly decreased with the increasing plant density. Results of combined ANOVA also showed that head diameter scored at different treatments did not influenced by year and the scores were 19.1 and 19.0 for 2007 and 2008 respectively. Results further indicated that interactive effect of Y × R × N was found significant ($P < 0.05$). Head diameter ranged 15.5-21.5 cm the highest head diameter was obtained from R2 × N3 in 2007.

1000 Seed Weight

1000 seed weight is one of the most important yield component in sunflower and environmental factors have an important impact on this character. Results of combined ANOVA showed that 1000 seed weight scored at different treatment influenced by N doses and years significantly. N doses showed the positive effects on 1000 seed weight compared to control. Average 1000 seed weight ranged from 102.6 g to 121.0 g. Maximum 1000 seed weight was recorded from N2 and further increase of N doses resulted in slight decline in 1000 seed weight. Average results of two years differed and 1000 seed weight obtained in 2007 was higher compared to 2008. Whereas, interactive effect of R × N was found non-significant. Average 1000 seed weight for two years ranged from 98.4 g to 127.7 g. Increase in 1000 seed weight due to the more access to absorb nutrients, supported by Zaman and Das (1991), Fathi *et al.,* (1997) and Gholinezhad *et al.,* (2009) who concluded that increasing level of N led to significant proliferation in 1000 seed weight.

Harvest index

Harvest index indicated the relative distribution of photosynthesis yield between economical yield and the biological yield of the plant. The effect of intra row spacing on harvest index was non-significant and the scores varied between 39.4 % and 39.5 %. Harvest index was significantly influenced by N levels and the average of two years were in the range of 36.2 % to 44.3 %. The maximum harvest index was obtained from N3 and the minimum was recorded from N0. In our research increased level of N had positive impact on harvest index and the results of this study showed contradiction with the Singh *et al.,* (1996), Gholinezhad *et al.,* (2009).

Hull Ratio

The data of hull ratio subjected to statistical analysis was significantly influenced by intra row spacing, year and the R × N interaction. But the hull ratio did not influenced by N doses. Average hull ratio of two years ranged from 44.5 % to 47.3 % with maximum hull ratio was obtained from R3. Results on impact of N doses on hull ratio had non-significant variation and the average of two year was in the range of 45.3 % to 47.2 %. Results also revealed that more hull ratio in 2007 compared to 2008 irrespective of intra row spacing and N doses. However results related the impact of the interaction between R × N found significant on hull ratio and the values ranged from 42.8 % to 49.2 %. The minimum hull ratio was recorded from R1 × N1 and the maximum was obtained from R3 × N1. In contrast to our data, Baldini and Vannozzi (1996) reported that increasing of hullability with the N.

Seed Yield Per Plant

Seed yield per plant significantly showed the significant effects of intra-row spacing. Average seed yield per plant of two years ranged from 84.9 to 99.1 g $plant^{-1}$ with minimum seed yield per plant which was recorded from 20 cm intra row space. Results on N doses showed the positive effects on seed yield per plant and the average was in the range of 80.1 - 99.6 g $plant^{-1}$. The maximum seed yield per plant was observed in N2 and the minimum was obtained from control. Effects of different N doses on the seed yield per plant was significantly differed during experiment years. Increasing N levels led to increase in seed yield per plant in both years but in 2008 N levels impact on seed yield per plant showed higher results compared to 2007. The seed yield per plant was 79.2 and 103.8 g plant^{-1} in 2007 and 2008 respectively. The interactive effect of R × N was not statistically significant and the average of two year was in the range of 68.7-105.5 g plant^{-1}. In previous studies similar results were reported by Aless *et al.,* (1997) and Gholinezhad *et al.,* (2009). Also Marinkovic (1999) observed that decrease in single plant grain yield of sunflower due to decreasing nutrient space of every plant with the increasing plant density.

Seed Oil Ratio

Results on seed oil ratio clearly showed the significant effects of intra row spacing ($P < 0.05$), N doses and interactive effect of R × N ($P < 0.01$). Average oil ratio of two years ranged from 43.4 % to 46.0 % with maximum oil ratio obtained from 20 cm space. The positive effect of N doses was observed on seed oil ratio compared to control. Average seed oil ratio ranged from 40.9 % to 47.4 %. Maximum oil ratio was recorded from N3 and further increase of N doses resulted in slight incline in seed oil ratio. Results also revealed higher seed oil ratio during 2008 compared to 2007 irrespective of row spacing or N dose. The low oil ratio probably caused by the diversity of precipitation between two years. Özer *et al.,* 2004 also reported that low rainfall during the vegetation stage of sunflower may lead to decline in oil concentration. Interactive effect of R × N was found significant and average seed oil ratio for two years ranged from 39. 7 % to 48.6 %. Maximum oil ratio was observed in the combination of R3 × N3. Contrarily, minimum oil was recorded from R3 × N0. Our results showed contradiction with Zubriski and Zimmerman (1974), Özer *et al.,* (2004) and Al thabet (2006) who implied that negative effect of N on oil ratio. However efficiency use of N by sunflower plant is possible with the N uptake from the soil and remobilization of stored vegetative N accumulated before the flowering stage. Steer *et al.,* (1984) and Ruffo *et al.,* (2003) also reported that when N uptake of sunflower is after the flowering stage, N negatively impacts the oil ratio. Therefore in this research application of N before sowing and at R-1 growth stage might led to increase in oil ratio comparing to control.

Seed Protein Ratio

Protein content one of the most important component of confectionery sunflower seeds. Results on seed protein ratio clearly showed the significant effect of N and Y × R × N. But the impact of intra-row spacing was statistically non-significant. Results of two years average about intra-row spacing on seed protein ratio was in the range of 28.3 % to 30.0 %. The minimum and the maximum scores were obtained from 20 cm and 40 cm respectively. Results on N doses revealed that the significant effect of N doses on protein ratio. The scores were in the range of 27.9 % to 29.5 %. Results further revealed that non-significant effect of R × N on seed protein ratio and scores varied between 26.6 % and 31.2 %. The results are in line with the previous results of Blamey and Chapman (1981), Steer *et al.,* (1986) and Özer *et al.,* (2004).

Seed Yield

Results of combined ANOVA showed that seed yield significantly affected by intra row spacing and N doses. Seed yield differed significantly within the years ($P < 0.01$). In 2008 when the precipitation was higher, the average seed yield was higher than 2007. The scored seed yield for 2007 and 2008, was 204.5 and 247.4 g da^{-1} respectively. Increasing number of plant with the 20 cm intra-row spacing led to considerable increase in seed yield. The average of two year observed was in the range of 198.6 kg da^{-1} to 263.0 kg da^{-1}. N had a significantly effect on seed yield and the average of two year varied between 202.7 and 244.0 kg da^{-1}. Interactive effects of R × N × Y had significant effects on seed yield. Every increasing level of N caused increase in all intra-row spacing (20, 30 and 40 cm). The highest seed yield within years obtained from R1 intra-row spacing and N3 treatment (Table 6). By plant density and N increase, seed yield per area became more due to the increase in the number of plants and N level per area. The results obtained from our research are in line with Ruffo *et al.,* (2003), Jahangir *et al.,* (2006), Beg *et al.,* (2007) and Day and Kolsarıcı (2014) who reported that seed yield of sunflower influenced by plant density.

Conclusion

Different level of intra row spacing and N had different impacts on plant. Among the most important results obtained about these treatments significant increase in yield at 20 cm intra-row spacing × 120 kg ha^{-1} observed. With plant density increase, decrease in 1000 seed yield was observed which means that small sized seeds were more. These results suggests that 30 cm intra row spacing and 80 kg ha^{-1} N treatment is suitable for Alaca genotype under Ankara conditions.

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