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Influence of Different Nitrogen Levels on Productivity of Oilseed and Confection Sunflowers (*Helianthus annuus* L.) Under Varying Plant Populations

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ABSTRACT

Study was conducted to determine the response of oilseed (P–6482) and confection (Inegol) sunflower cultivars to plant density and nitrogen in 2001 growing season. The experiment comprised of three plant populations [23800 (P1), 35710 (P2) and 71420 (P3) plant ha^{-1}] and nitrogen levels [0 (N_0), 60 (N_{60}) & 120 (N_{120}) kg ha^{-1})]. Plant height, head diameter, total number of seeds $head^{-1}$, seed setting efficiency, seed yield $head^{-1}$, 1000–seeds weight, dehulled seed ratio, seed oil content, seed and oil yield of confection sunflower, all the characteristics mentioned above except dehulled seed ratio of oilseed sunflower were significantly affected by plant populations. It was determined that the lowest plant populations (P1) resulted in the highest head diameter, total number of seeds $head^{-1}$, seed yield $head^{-1}$ and 1000–seed weight while the highest plant populations (P3) resulted in the highest oil content, seed and oil yield in both varieties. Nitrogen levels had significantly affected on total number of seeds $head^{-1}$, seed setting efficiency, seed yield $head^{-1}$, 1000–seeds weight, seed and oil yield of oilseed and confection sunflowers. N_{60} treatment gave highest seed (4.3 t ha^{-1}) and oil yield (1.7 t ha^{-1}).

Key Words: Sunflower; Nitrogen; Plant populations

INTRODUCTION

Turkey has been facing a recurring shortage of vegetable oils for many years due to fluctuations in the production of oil seeds. Presently, over 50% of vegetable oil being consumed in Turkey has to be imported. Turkey has a suitable climate for many oilseeds (Ozer, 2003). Sunflower can be grown successfully when it is seeded as spring–sown crop under irrigated and rainfed conditions of Kahramanmaras province (Killi, 1997). However, there are no published research data on the nitrogen rate and plant population response of sunflower in the region.

Nitrogen is the most common element limiting sunflower yield (Zubriski & Zimmerman, 1974). Yield response of sunflower to increasing N rate and plant density varies with different environmental variables, including weather, soil type, residual fertility (especially nitrate), soil moisture, and cultivar. Previous study (Coic *et al.,* 1972; Zubriski & Zimmerman, 1974) revealed that nitrogen reduced oil percentage of the seed. Nitrogen increases seed and oil yields by influencing a number of growth parameters such as seeds per head and seed weight and by producing more vigorous growth and development (Wagh *et al.,* 1991; Faizani *et al.,* 1990; El–Naggar, 1991; Sarmah *et al.,* 1992). Kene *et al.* (1992) and Faizani *et al.* (1990) found that oil content of sunflower was not affected by increasing N rate. On the other hand, excessive use of N fertilizer can decrease seed oil content (Narwal & Malik, 1985; Wagh *et al.,* 1991; Sindhu *et al.,* 1991; Tripathi & Sawhney, 1989; El–Naggar, 1991; El–Naggar & Allam, 1991). For oilseed sunflower, Monotti (1978) also found that seed yield and oil content declined with rates of N up to 100 kg ha^{-1}.

Numerous research studies for different climates have shown that plant density influences the growth, seed yield and quality of sunflower (Getmanets *et al.,* 1991; Harmati, 1992; Sterjo, 1989; Patil *et al.,* 1992). Studies by Narwal and Malik (1985) showed that as plant density was increased head diameter, number of seeds per head and 100–seed weight decreased while seed yield increased. Sterjo (1989) and Kene *et al.* (1992) also suggested that increased plant density resulted in a significant increase in seed yield. Similarly, Killi & Özdemir (2001) reported that denser sowings (7.1–10 plant m^{-2}) resulted in higher (30%) yields in hybrid oilseed sunflower than lower plant densities (4.1–5.7 plant m^{-2}). Robinson *et al.* (1980), Chavan *et al.* (1990) and Killi and Özdemir (2001) reported that as plant populations were increased, seed oil content increased. However, Narwal and Malik (1985), Villalobos *et al.* (1992) and Kene *et al.* (1992) found that plant density had no effect on seed oil content. Thus, determining optimum management practices are likely to be of critical importance in different ecological conditions. The objective of this study was to determine the appropriate plant populations and nitrogen levels in sunflower production for either Kahramanmaras or East Mediterranean climate.

MATERIALS AND METHODS

Two sunflower cultivars (*Helianthus annuus* L.) were selected based on their adaptation to the sunflower production areas in the East Mediterranean Region of Turkey. P–6482 and İnegöl sunflower cultivars have been successfully grown under rainfed and irrigated conditions of this region. P–6482 was selected because of having relatively small seeds, hybrid and oilseed. İnegöl was selected because of having relatively large seeds, composite and confection. These two sunflower varieties were evaluated for plant height, head diameter, total number of seeds head^{-1}, seed setting efficiency, seed yield head^{-1}, 1000–seeds weight, dehulled seed ratio, seed oil content, seed and oil yield at three plant populations [23800 (P1), 35710 (P2) & 71420 (P3) plant ha^{-1}] and nitrogen levels [0 (N_0), 60 (N_{60}) & 120 (N_{120}) kg ha^{-1})] in 2001 at the Agricultural Research Institute of Kahramanmaras, Turkey. Kahramanmaras province is located in the East–Mediterranean region of Turkey between 37^o 36^1 north parallel and 46^o 56^1 east meridians. The soil was an alluvial clay loam with the mean properties as pH=7.5, organic matter=1.7%, N=0.05%, $CaCO_3$=19.8%, available P=5.15 kg da^{-1}, and available K=7.3 kg da^{-1}. Based on soil test conducted in test year, phosphorus and potassium at the rate of 60 kg P_2O_5 and K_20 ha^{-1} were applied, respectively. Nitrogen was applied as split in two application (N_{30+30} & N_{60+60}); half with sowing and the remaining half at the R_1 stage (Schneiter & Miller, 1981). Cultural practices, control of insects and weeds and furrow irrigation were given as needed during the growth season according to the local recommendations. All other production practices were recommended standards.

The trials were conducted using a randomized complete block design with split–plot arrangement keeping with plant populations as main plots and nitrogen levels as subplots. Each subplot consisted of 4 rows 7 m in length with 70 cm between rows. Individual plots were spaced 2.8 m apart. Each treatment was replicated three times. The sunflower seeds were sown by putting three seeds to hills by hand. Plants were thinned to one plant per hill 15 days after sowing. Ten randomly tagged plants from each plot were evaluated for plant height, head diameter, total number of seeds head^{-1}, seed setting efficiency, seed yield head^{-1} and 1000–seeds weight. Achenes were separated into nonempty and empty. Nonempty achenes were counted, oven dried (with air circulating at 60°C) to constant weight, and weighed. Seed setting efficiency were calculated from nonempty and empty achenes as *(nonempty achenes/nonempty+empty achenes) X 100*. Seed yield were obtained from an area 1.4 m wide and 5 m long of the center two rows of each plot. Seed samples were collected from each plots and ground with an electric coffee mill. A small portion of ground seeds (5 g) was transferred to a disposable filter column and seed oil content was determined by the Soxhlet apparatus. Dehulled seed ratio was determined following the procedure reported by Urie *et al.* (1968). In the experiments, confection and oilseed sunflower cultivars were harvested on 23th August and 5th September by hands, respectively. Data were analyzed using the MSTAT–C statistical package programme. When the *F*–test indicated statistical significance at the *P*=0.05 level, the protected least significant difference (Protected LSD) was used to separate the means.

RESULTS AND DISCUSSION

Confection sunflower. Data pertaining to confection sunflower (Inegöl) are presented in Table I. All investigated characteristics were significantly affected by plant populations. Although the P1 treatment produced the highest head diameter, number of total seeds head^{-1}, seed setting efficiency, seed yield head^{-1} and 1000–seeds weight, the P3 treatment gave the highest plant height, dehulled seed ratio, seed oil content, seed and oil yield. With increasing plant density, seed yield head^{-1} generally tended to decrease. The yield head^{-1} reductions in confection sunflower at high density can be explained by lower head diameter, number of total seeds head^{-1}, seed setting efficiency and 1000–seeds weight. This reduction in seed yield head^{-1} with increasing plant populations has been verified in early field studies (Günel, 1971). Robinson *et al.* (1980) working with sunflower, also founded that high plant density produced small heads. Although head diameter, number of total seeds head^{-1}, seed setting efficiency, seed yield head^{-1} and 1000–seeds weight reduced with increasing plant density, the plant height, dehulled seed ratio, seed oil content, seed and oil yield increased. Narwal and Malik (1985) reported that as plant density was increased head diameter, number of seeds head^{-1} and 1000–seeds weight decreased while seed yield (kg ha^{-1}) increased. Similar observations were made by Sterjo (1989), Kene *et al.* (1992) and Killi and Özdemir (2001), who reported that increased plant density resulted in a significant increase in seed yield.

N treatments significantly increased head diameter, number of total seeds head^{-1}, seed setting efficiency, seed yield head^{-1}, 1000–seeds weight, seed and oil yield (Table I). N levels had no significant effect on yield components, such as plant height, dehulled seed ratio and seed oil content. These results are in line with those of Kene *et al.* (1992) and Faizani *et al.* (1990) found that oil content was not affected by increasing N rate. N_{60} and N_{120} treatments produced the highest head diameter, number of total seeds head^{-1}, seed yield head^{-1}, 1000–seed weight, seed and oil yield except seed setting efficiency. Maximum seed setting efficiency (85.33%) was produced when nitrogen was applied at the rate of 60 kg ha^{-1}. When nitrogen was increased from N_{60} to N_{120}, the seed setting efficiency was reduced approximately 3%. The minimum values for investigated traits were generally recorded in N_0 treatment. Head diameter, number of total seeds head^{-1}, seed setting efficiency, and 1000–seeds weight are commonly four

Table I. Effects of different nitrogen levels on productivity of confection sunflower (Inegöl) under varying plant populations

	Plant height (cm)	Head diameter (cm)	Total seed (No. head^{-1})	Seed setting efficiency (%)	Seed yield (g head^{-1})	1000-Seed weight (g)	Dehulled seed ratio (%)	Seed oil content (%)	Seed yield (kg ha^{-1})	Oil yield (kg ha^{-1})
Plant populations (P)										
23800 (P1)	185.00 c	22.38 a	1361.33 a	86.33 a	144.74 a	123.19 a	53.17 b	26.68 b	3444.8 c	919.2 c
35710 (P2)	189.22 b	19.08 b	1279.22 b	82.11 b	114.57 b	111.46 b	55.13 a	28.02 ab	4090.1 b	1146.2 a
71420 (P3)	192.89 a	15.83 c	941.67 c	80.33 b	76.38 c	98.29 c	55.41 a	28.94 a	4689.5 a	1357.1 b
LSD $_{0.05}$	1.18	0.87	32.64	3.63	6.56	3.96	0.81	1.56	209.3	73.7
Nitrogen levels (N)										
0 (N_0)	188.00	18.58 b	1147.67 b	80.44 c	96.95 b	102.83 b	55.19	28.04	3471.0 b	978.6 b
60 (N_{60})	188.89	19.21 a	1222.78 a	85.33 a	121.19 a	114.41 a	54.44	27.43	4419.8 a	1219.3 a
120 (N_{120})	190.22	19.49 a	1211.77 a	83.00 b	117.56 a	115.72 a	54.08	28.12	4333.6 a	1220.7 a
LSD $_{0.05}$	ns	0.50	54.83	2.28	4.62	2.65	ns	ns	14.09	57.9
P x N	ns	ns	ns	ns	ns	ns	ns	ns	**	ns

Table II. Effects of different nitrogen levels on productivity of oilseed sunflower (P-6482) under varying plant populations

	Plant height (cm)	Head diameter (cm)	Total seed (no. head^{-1})	Seed setting efficiency (%)	Seed yield (g head^{-1})	1000-Seed weight (g)	Dehulled seed ratio (%)	Seed oil content (%)	Seed yield (kg ha^{-1})	Oil yield (kg ha^{-1})
Plant populations (P)										
23800 (P1)	168.56 c	23.16 a	1944.44 a	90.67 b	131.50 a	74.48 a	70.83	38.76 b	3129.7 c	1213.1 c
35710 (P2)	174.44 b	20.35 b	1860.67 b	91.56 ab	108.32 b	63.17 b	70.99	39.48 ab	3866.8 b	1526.6 b
71420 (P3)	177.33 a	17.41 c	1650.00 c	91.89 a	85.05 c	56.05 c	71.01	41.31 a	5222.3 a	2157.3 a
LSD $_{0.05}$	2.50	0.83	48.64	1.05	2.23	0.47	ns	2.33	142.2	65.0
Nitrogen levels (N)										
0 (N_0)	175.67	20.11	1781.89 c	84.78 b	92.59 b	60.84 b	71.60	39.92	3472.3 b	1386.1 b
60 (N_{60})	171.56	20.43	1818.11 b	94.66 a	115.39 a	66.61 a	71.56	39.68	4376.7 a	1736.6 a
120 (N_{120})	173.11	20.39	1855.11 a	94.67 a	116.89 a	66.25 a	70.56	39.94	4372.7 a	1746.4 a
LSD $_{0.05}$	ns	ns	34.69	1.72	2.13	1.28	ns	ns	93.7	46.5
P x N	ns	ns	ns	ns	ns	ns	ns	ns	**	ns

*, ** significant at the 0.05 and 0.01 level, respectively; For each main effect, values within columns followed by the same letter are not significantly at P= 0.05; ns, non-significant

major determinants of sunflower yield. The plant population X nitrogen level interaction was significant for seed yield (Fig. 1). The application of N fertilizer could not compensate for the yield losses due to the low plant density. Seed yield of sunflower was much altered by N–fertilization as suggested by Faizani *et al.* (1990), El–Naggar, (1991), Wagh *et al.* (1991) and Sarmah *et al.* (1992). Maximum seed yield was approximately 4420 and 4337 kg ha^{-1} attained at N rate of 60 and 120 kg ha^{-1}, respectively; which clearly suggest the importance of nitrogen for higher seed production in confection sunflower crop. However, significant yield increases with application of nitrogen up to only 60 kg ha^{-1} was observed (Table I). Yield increased in a quadratic fashion in confection sunflower (Fig. 2). High R^2 (1.00) indicates a close relationship between seed yield and nitrogen levels. Nitrogen rate recommendations are location–specific and affected by environmental conditions, although the rate of 60 kg N ha^{-1} is optimum N amount for this region.

Oilseed sunflower. Yield and yield components of oilseed sunflower (P–6482) are presented in Table II, which indicate that all investigated characteristics were significantly affected by plant populations except dehulled seed ratio. Although the P1 treatment produced the highest head diameter, number of total seeds head^{-1}, seed yield head^{-1} and 1000–seeds weight, the P3 treatment gave the highest plant height, seed setting efficiency, seed oil content, seed and oil yield. With increasing plant density, seed yield head^{-1} generally tended to decrease. The yield head^{-1} reductions in oilseed sunflower at high density can be explained by lower head diameter, number of total seeds head^{-1} and 1000–seeds weight. This reduction in seed yield head^{-1} increasing plant populations has been verified in some studies (Günel, 1971; Robinson *et al.*, 1980). Although head diameter, number of total seeds head^{-1}, seed yield head^{-1} and 1000–seeds weight reduced with increasing plant density, the plant height, seed setting efficiency, seed oil content, seed and oil yield increased. Numerous research studies for different climates have shown that plant density influences the growth, seed yield and quality of sunflower (Sterjo, 1989; Getmanets *et al.,* 1991; Harmati, 1992; Patil *et al.,* 1992). The present results were in a good agreement with the finding of Narwal and Malik (1985), Sterjo (1989), Kene *et al.* (1992), and Killi and Özdemir (2001), who

Fig. 1. Influence of plant population and nitrogen level on seed yield of confection sunflower

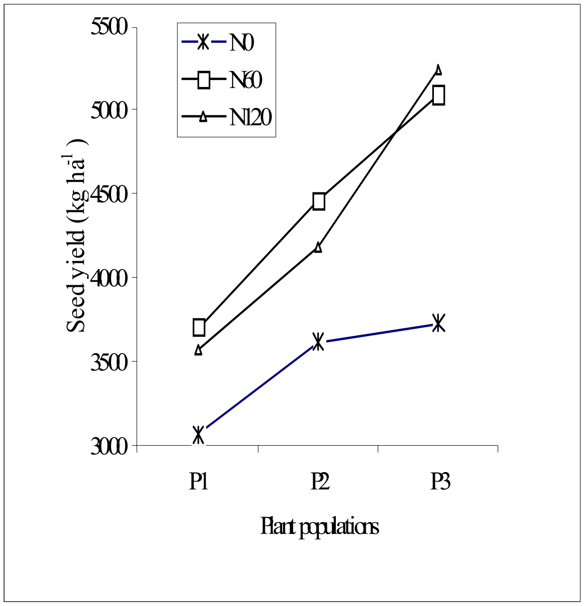


Fig. 2. Seed yield as a function applied in confection sunflower cultivar (Inegöl)

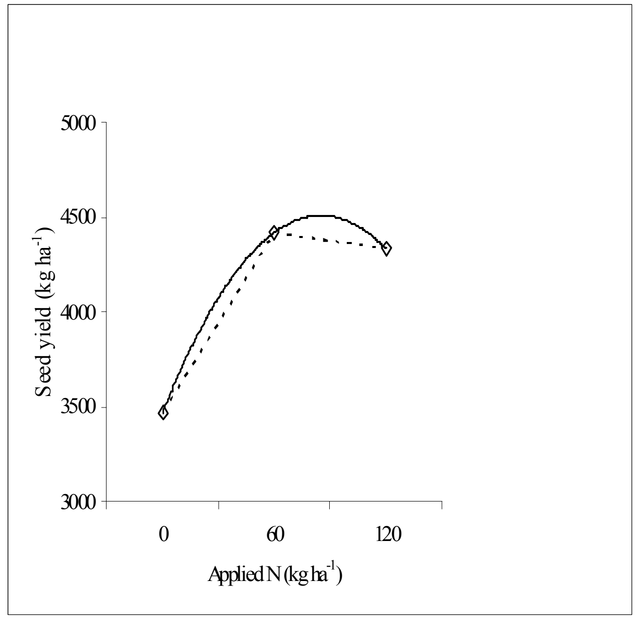


Fig. 3. Influence of plant population and nitrogen level on seed yield of oilseed sunflower (P-6482)

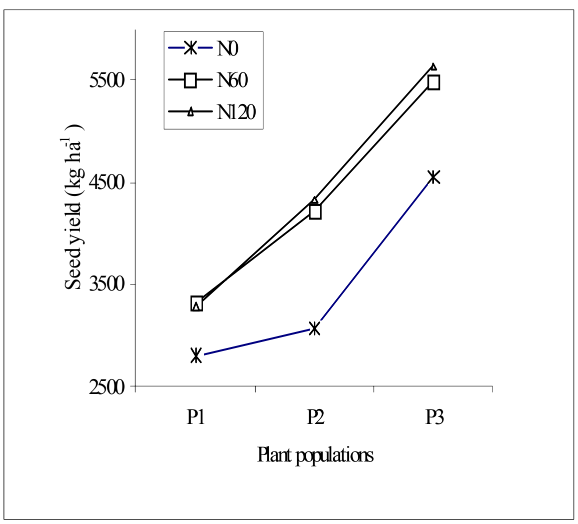
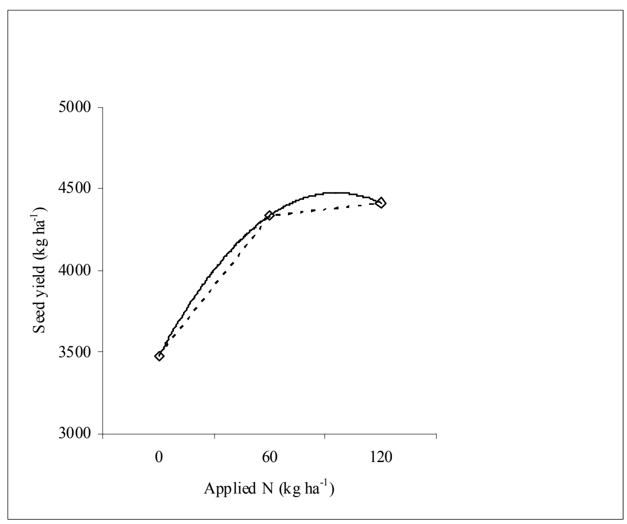


Fig. 4. Seed yield as a function applied in oilseed sunflower cultivar (P-6482)



reported that increased plant density resulted in a significant increase in plant height, seed setting efficiency, seed oil content, seed and oil yield.

N treatments significantly increased number of total seeds head^{-1}, seed setting efficiency, seed yield head^{-1}, 1000–seeds weight, seed and oil yield (Table II). N rates had no significant effect on plant height, head diameter, dehulled seed ratio and seed oil content. These results are in line with those of various researchers reported that the nitrogen had no significant effect on plant height (Herdem, 1999), head diameter (Monotti, 1978), dehulled seed ratio (Herdem, 1999) and seed oil content (Faizani *et al.*, 1990; Kene *et al.,* 1992). N_{60} and N_{120} treatments produced the highest seed setting efficiency, seed yield head^{-1}, 1000–seed weight, seed and oil yield. Maximum number of total seeds head^{-1} (1855.11 no. head^{-1}) was produced when nitrogen was applied at the rate of 120 kg ha^{-1}. The minimum values for investigated traits were generally recorded in N_0 treatment. When nitrogen was increased from N_0 to N_{60}, the seed setting efficiency, seed yield head^{-1}, 1000–seeds weight, seed and oil yield were increased approximately 12, 25, 9, 26 and 25%, respectively. Nitrogen increases seed and oil yields by influencing a number of growth parameters such as seeds per head and seed weight and by producing more vigorous growth and development (Faizani *et al.,* 1990; Wagh *et al.,* 1991; El–Naggar, 1991; Bindra & Kharwara, 1992; Sarmah *et al.,* 1992). The plant population X nitrogen level interaction was significant for seed yield (Fig. 3). The application of N fertilizer could not compensate for the yield losses due to the low plant density. Maximum seed yield was approximately 4376 kg ha^{-1} and 4372 kg ha^{-1} which were attained at N rate of 60 and 120 kg ha^{-1}. This result clearly indicated the importance of nitrogen for higher seed production in oilseed sunflower. However, significant yield increases with application of nitrogen up to only 60 kg ha^{-1} was observed (Table II). Yield increased in a quadratic fashion in oilseed sunflower (Fig. 4). High R^2 (1.00) indicates a close relationship between seed yield and nitrogen rates. Nitrogen rate recommendations are location–specific and affected by environmental conditions, although the rate of 60 kg N ha^{-1} is optimum N amount for this region. Therefore, knowledge of the residual soil N, rate, and amount of N mineralized from soil organic sources, and individual crop needs are required to optimize N fertilizer recommendations.

CONCLUSIONS

It can be concluded that confection (Inegöl) and oilseed (P–6482) sunflower should be sown in high populations (71420 plant ha^{-1}) with nitrogen application rate of 60 kg ha^{-1} to obtain maximum seed and oil yield.

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