HELIA, **33**, Nr. 53, p.p. 207-214, (2010) UDC 633.854.78:631.84:631.53.04
DOI: 10.2298/HEL1053207S

EFFECTS OF NITROGEN AND PLANT DENSITY ON DWARF SUNFLOWER HYBRIDS

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Received: April 10, 2010
Accepted: August 10, 2010

SUMMARY

This research was carried out to determine the seed yield and some yield components of two dwarf hybrids as compared to one standard-height sunflower hybrid (*Helianthus annuus* L.) at different nitrogen rates and planting densities. The study was carried out under natural rainfed conditions at the Thrace Agricultural Research Institute in Edirne-Turkey between 1999 and 2001. The experiments were set up in split-split plots in a randomized complete block design with three replications. The main plot treatments were three different-height sunflower hybrids, DW-1, DW-2, and Trakya-80. The sub plots were three levels of nitrogen, 0, 60, and 120 kg N/ha. The sub-sub plots were three planting densities, 10 × 70 (142,850 plants/ha), 15 × 70 (95,230 plants/ha), and 20 × 70 cm (71,430 plants/ha). Based on marginal economic analyses, the economically optimal seed yield per hectare was obtained at 50 kg N/ha for DW-1 and at 80 kg N/ha for DW-2 and Trakya-80. In all three hybrids, increasing plant densities decreased 1000-seed weight, hull percentage, and head diameter but increased test weight in natural rainfed conditions. The highest seed yield in both dwarf hybrids was obtained with the spacing of 15 × 70 cm (95,230 plants/ha). The results of this research show that nitrogen and plant density have significant effects on seed yield and some yield components of different-height sunflower hybrids.

Key words: **sunflower, dwarf, nitrogen, plant density**

INTRODUCTION

The sunflower (*Helianthus annuus* L.) is one of the most widely cultivated oil crops in the world. It is also grown widely in the Trakya-Marmara region of Turkey. Turkish farmers use oilseed sunflower varieties of different heights. These different varieties needs different plant densities and nitrogen requirements in order to produce high seed and oil yields per hectare. In particular, early-maturing dwarf and semi-dwarf hybrids used for commercial production have led to a change in plant

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population, row spacing and fertilizer rate recommendations compared to those used for conventional hybrids. Dwarf hybrids generally perform the best when grown at high plant populations, and they also maintain yield levels better than conventional hybrids when planted on later dates (Majid and Schneiter, 1987; Gubbels and Dedio, 1990; Hussain, 1990; Feoli and Schneiter, 1993; Süzer and Atakişi, 1994; Göksoy and Turan, 1999). In commercial sunflower production, higher plant populations are recommended for dwarf sunflower hybrids when the grower wants to achieve optimum seed yield performance.

Some advantages of the reduced-height hybrids are high resistance to lodging and easy cultivation and harvesting. Scientific data on the performance and agronomic characteristics of the reduced-height hybrids at different plant populations per hectare is limited. Stand density can influence sunflower grain yields, which depend on three components. These are the number of heads per hectare, number of seeds per head, and 1000-seed weight. The optimum plant population used in various production areas throughout the world shows variation. In some experiments, the results showed that higher seed yields and oil contents were obtained with increasing plant populations (Robinson *et al.*, 1980; Vannozzi and Baldini, 1988). However, it has also been reported that different plant populations had no effect on seed yield (Prunty, 1983).

Plant population affects other plant characteristics as well. As plant population is increased from low to high, the flowering stage was delayed, plant height increased, the plants lodged more, and seed size, head and stalk diameter decreased (Vranceanu *et al.*, 1982; Brigham and Young, 1985; Fick *et al.*, 1985; Miller and Hommond, 1989). The performances of tall, semi-dwarf and dwarf sunflower hybrids are different at various plant populations. The reduced-height sunflower hybrids responded better to high plant populations than the standard and tall hybrids did (Stanojević, 1989; Vannozi and Baldini, 1990; Feoli, 1993; Fick *et al.*, 1985; Johnson, 2002).

Many fertilizer studies have shown that sunflower responds to fertilizer use. Nitrogen, phosphorus and potassium (NPK) in particular are few of the major nutrients required to significantly increase sunflower yields. Fertilizer application rates in sunflower production vary because of the variable occurrence of NPK in the soil. Nitrogen is a common element limiting sunflower yields (Süzer and Uludere, 1997; Süzer, 1998).

In the Trakya region of Turkey, some farmers believe that oilseed sunflowers do not require as much fertilizer as the other field crops. Actually, sunflower has an extensive root system that may help in the utilization of residual soil nutrients that have been given to wheat as a rotation crop. According to researches on sunflower production, the N budget/ha in the soil for a 2,000 kg seed crop amounts to 48 kg for the seed, 31 kg for the stover, 3 kg for the roots and 14 kg for the soil microflora - a grand total of about 100 kg N (Robinson, 1978).

The objectives of this study were to determine the seed yield and some yield components of two dwarf hybrids compared with one standard-height sunflower hybrid at different nitrogen rates and planting densities under natural rainfed conditions.

MATERIALS AND METHODS

This research was conducted between 1999 and 2001 at the Thrace Agricultural Research Institute in Edirne, which is located in the European part of Turkey. The main properties of the soil used in the field experiments are presented in Table 1. The fertilizer used in the experiment area was in accordance with the results of soil analyses.

Table 1: Main properties of soil used in the field experiments.

Year	Depth (cm)	Dry/ wet	Water saturation (%)	pH	Texture class	P_2O_5 (ppm)	K_2O (ppm)	Ca (ppm)	Zn (ppm)	Organic matter (%)
1999	0-30	Dry	50	6.07	Silt	33.4	351.0	2442	0.867	1.4
2000	0-30	Dry	50	6.12	Silt	26.7	316.0	2665	0.459	1.1
2001	0-30	Dry	44	6.26	Silt	32.7	337.0	2612	0.659	1.2

Three oilseed-type sunflower hybrids of different height (two dwarf and one standard), DW-1, DW-2, and Trakya-80, were used as the experiment material. The hybrids were developed at the Trakya Agricultural Research Institute in Edirne.

The experiments were established in a split–split plot design in RCBD with three replications. The main plots had sunflower hybrids of three different heights: DW-1, DW-2, and Trakya-80. The sub plots were three different nitrogen rates; 0, 60, and 120 kg N. The sub-sub plots were three different planting densities; 10 × 70 cm (142,850 plants/ha), 15 × 70 cm (95,230 plants/ha) and 20 × 70 cm (71,430 plants/ha).

Plot size at planting was 2.8 × 7.5 m=21.0 m^2, while plot size at harvesting was 1.4 × 6.9=9.7 m^2. The fertilizer required for each plot according to the experimental design was broadcast prior to planting manually. The intra-row spacing was 10, 15, and 20 cm, while the rows were spaced 70 cm apart.

The trial was carried out in rotation with wheat. The materials were planted in April. The hills on the plots were over-planted and then thinned to one plant per hill three weeks after sowing. Weed control was accomplished using both chemicals and cultural practices.

Mean values of seed yield, oil content, oil yield, 1000-seed weight, test weight, plant height, head diameter, time to flowering and time to physiological maturity were determined in each plot and analyzed using ANOVA. Regression analysis was applied to find the relationships between fertilizer rates and seed yield and also between fertilizer rates and oil yield (Little and Hills, 1978; Russell, 1986).

RESULTS AND DISCUSSION

Presented in Tables 2, 3, 4, and 5 are the effects of different nitrogen rates and planting densities on seed yield and some yield components of dwarf and standard height sunflower hybrids under natural rainfed conditions between 1999 and 2001. The relationship between the seed yields of DW-1, DW-2 and Trakya-80 and nitrogen rates is shown in Figure 1. The maximum and economically optimal seed yields of the three sunflower hybrids were calculated from regression equations as a response to fertilizer rates and are given in Table 6.

As seen in Table 2, as a main plot, the two dwarf and one standard-height sunflower hybrids affected significantly ($p \leq 0.01$ and $p \leq 0.05$) the mean oil content, oil yield, 1000-seed weight, test weight, hull percentage, and plant height at three nitrogen rates and planting densities over three study years. In the three-year growing period, standard-height sunflowers outperformed the two dwarf hybrids and gave the highest seed yield (2,266 kg/ha). Feoli *et al.* (1993) obtained similar results when comparing the agronomic performance of dwarf, semi-dwarf, and conventional-height sunflower hybrids grown at five plant populations under rainfed field conditions in North Dakota, USA.

Table 2: As a main plot, mean seed yield and yield components of two dwarf and one standard-height sunflower hybrids at three nitrogen rates and planting densities between 1999 and 2001.

No.	Variety	Seed yield (kg/ha)	Yield rank	Oil in seed (%)	Oil yield (kg/ha)	1000-seed weight (g)	Test weight (kg/Hl)	Hull %	Plant height (cm)	Head diameter (cm)
1	DW-1	1988	2	38.4	763	41.8	40.8	28.3	84.7	11.6
2	DW-2	1934	3	39.2	759	40.1	42.5	27.8	82.2	11.6
3	Trakya-80	2266	1	43.6	983	36.2	40.3	24.4	122.0	12.4
LSD (0.05)		473^{ns}		0.5**	150*	1.7*	1.6*	0.8*	15.2**	0.3
C.V.(%)		12.1		2.3	9.1	4.9	1.0	4.4	5.1	7.4

*, ** : Significant at 0.05 and 0.01 levels.

Table 3: Mean seed yield and yield components of sunflowers as affected by three levels of nitrogen as a sub plot average of three seasons (1999 to 2001).

No.	Nitrogen rates (ha)	Seed yield (kg/ha)	Yield rank	Oil in seed (%)	Oil yield (kg/ha)	1000-seed weight (g)	Test weight (kg/Hl)	Hull (%)	Plant height (cm)	Head diameter (cm)
1	N0	1853	3	39.8	739	39.4	41.6	26.5	95.7	11.3
2	N60	2168	1	40.4	879	39.6	41.2	27.8	96.3	11.9
3	N120	2166	2	40.4	876	39.1	41.0	26.6	97.0	12.4
LSD(0.05)		246**		0.4**	71**	0.9	0.6**	0.5**	3.9	0.6*
C.V.(%)		12.1		2.3	9.1	4.9	1.0	4.4	5.1	7.4

*, ** : Significant at 0.05 and 0.01 levels.

As seen in Table 3, as a sub plot, nitrogen rates affected the mean seed yield, oil content, oil yield, test weight, hull percentage, and head diameter of two dwarf and one standard-height sunflower hybrids significantly ($p \leq 0.01$ and $p \leq 0.05$). Based on three-year growing season data, the nitrogen rate of 60 kg/ha gave the highest mean seed yield (2,168 kg/ha). Similar results have been reported by Arslan (1989) and Süzer (1998), who conducted studies on nitrogen rates in sunflower under Trakya field conditions.

As seen in Table 4, as a sub-sub plot, three plant densities affected the mean 1000-seed weight, test weight, hull percentage, and head diameter of two dwarf and one standard-height sunflower hybrids significantly ($p \leq 0.01$ and $p \leq 0.05$). Based on three-year growing season data, the spacing of 15 × 70 cm, or 95,230 plants per hectare, gave the highest mean seed yield (2,132 kg/ha) of all the plant densities.

Table 4: Mean seed yield and yield components of sunflower as affected by three planting densities as a sub-sub plot average of three seasons (1999 to 2001).

No.	Plant density	Seed yield (kg/ha)	Yield rank	Oil in seed (%)	Oil yield (kg/ha)	1000-seed weight (g)	Test weight (kg/Hl)	Hull %	Plant height (cm)	Head diameter (cm)
1	10×70	2014	3	40.4	814	37.9	42.0	26.5	96.1	11.1
2	15×70	2132	1	40.5	866	39.2	41.3	26.8	95.9	12.0
3	20×70	2043	2	39.9	817	41.6	40.6	27.5	97.0	12.7
LSD(0.05)		367		0.8	10.1	2.4**	0.7**	1.2**	6.3	1.1**
C.V.(%)		12.1		2.3	9.1	4.9	1.0	4.4	5.1	7.4

*, ** : Significant at 0.05 and 0.01 levels

As seen in Figure 1 and Table 6, the correlation coefficient values of DW-1 (R=0.778**), DW-2 (R=0.857**) and Trakya-80 (R=0.833**) were found to be significant. Regression equations for DW-1 ($Y=1906.0+4.56\,X-0.031\,X^2$), DW-2 ($Y=1636.0+11.18\,X-0.064\,X^2$) and Trakya-80 ($Y=2019.6+8.35\,X-0.042\,X^2$) were also found to be significant. Based on marginal economic analyses, the economically optimal seed yield per hectare was obtained at 50 kg N/ha for DW-1 and at 80 kg N/ha for DW-2 and Trakya-80.

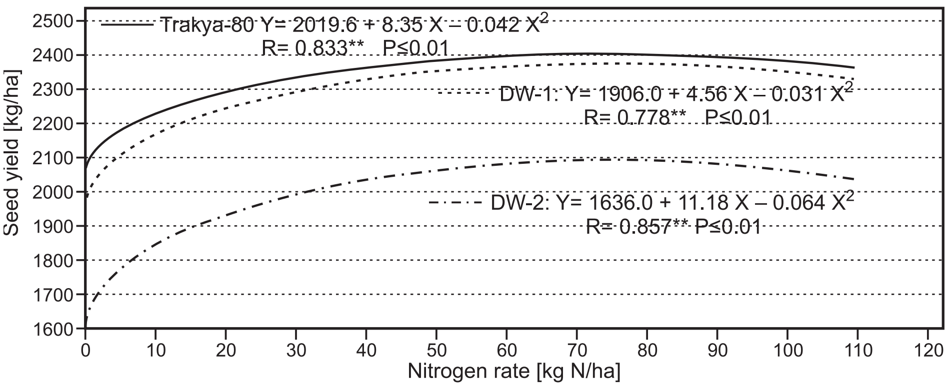

Figure 1: Relationship between seed yields of DW-1, DW-2 and Trakya-80 and nitrogen rates.

In all three hybrids, increasing plant densities decreased 1000-seed weight, hull percentage, and head diameter but increased test weight in natural rainfed conditions. The highest seed yield in both dwarf hybrids was obtained with the spacing of 15 × 70 cm (95,230 plants/ha).

As seen in Table 5, the highest seed yield (2,585 kg/ha) was obtained at 120 kg N/ha and the spacing of 20 × 70 cm (71,430 plants/ha) with the standard-height hybrid Trakya-80. The second highest seed yield (2,231 kg/ha) was obtained at 120 kg N/ha and 15 × 70 cm (95,230 plants/ha) with DW-2. DW-1, however, produced the highest seed yield at 60 kg N/ha and a plant density of 15 × 70 cm (95,230 plants/ha).

Table 5: Mean seed yield and yield components of three sunflower hybrids as affected by three nitrogen levels and three planting densities over three seasons (1999 to 2001).

No	Variety name	N rate (kg/ha)	Plant density	Seed yield (kg/ha)	Yield rank	Oil in seed (%)	Oil yield (kg/ha)	1000-seed weight (g)	Test weight (kg/Hl)	Hull %	Plant height (cm)	Head diameter (cm)	Flowering time	Physiological matur. time
1		0	10×70	1938	20	36.4	704	41.5	42.2	28.1	83.9	10.6	64.6	107.2
2		0	15×70	1899	22	37.1	705	42.5	41.3	28.7	84.3	11.1	64.3	108.7
3		0	20×70	1882	23	37.3	702	45.5	40.3	29.4	86.5	11.6	63.3	109.5
4		60	10×70	2033	15	38.3	779	39.8	41.5	29.1	82.8	10.4	61.7	107.2
5	DW-1	60	15×70	2097	11	37.6	789	41.3	40.2	29.2	82.8	11.3	62.5	107.3
6		60	20×70	2057	13	38.5	790	44.4	40.4	28.1	85.7	12.5	62.2	107.7
7		120	10×70	2036	14	39.4	805	39.4	41.4	27.2	87.8	11.6	61.3	106.3
8		120	15×70	2070	12	39.5	816	39.9	40.9	28.7	83.2	12.0	61.2	107.0
9		120	20×70	1881	24	39.6	743	42.5	39.7	27.1	85.6	13.1	61.8	107.0
10		0	10×70	1579	26	37.5	591	36.5	44.4	28.1	77.9	9.4	66.0	111.5
11		0	15×70	1761	25	39.6	696	40.5	43.3	26.3	80.8	11.1	65.7	111.5
12		0	20×70	1568	27	38.4	601	43.4	41.8	27.1	84.8	12.1	65.3	111.8
13		60	10×70	2117	9	40.3	856	38.1	43.5	28.5	80.5	11.0	64.0	110.7
14	DW-2	60	15×70	2207	8	38.6	870	41.5	42.9	27.5	83.7	12.3	65.0	111.2
15		60	20×70	1901	21	39.4	748	41.8	41.5	28.5	83.3	12.6	65.2	111.2
16		120	10×70	2027	16	40.5	822	37.4	42.8	28.1	82.0	11.5	63.8	107.8
17		120	15×70	2231	5	40.3	899	40.3	42.2	27.5	84.7	12.6	63.7	108.2
18		120	20×70	2021	17	38.4	776	41.1	41.0	29.1	82.3	12.0	63.5	108.7
19		0	10×70	1965	19	43.6	856	30.6	40.8	24.4	122.8	11.3	66.0	112.3
20		0	15×70	1990	18	44.9	892	34.3	39.9	23.5	119.6	12.1	67.2	113.7
21		0	20×70	2104	10	43.5	912	40.6	40.2	23.3	121.0	12.6	67.0	112.3
22		60	10×70	2215	7	43.8	970	34.7	40.6	24.5	125.8	11.3	64.7	109.8
23	TR-80	60	15×70	2497	2	44.1	1102	34.6	39.9	25.2	120.1	12.1	64.0	110.0
24		60	20×70	2393	4	43.6	1044	40.2	40.3	28.6	121.6	13.4	64.2	110.7
25		120	10×70	2213	6	43.7	967	37.8	40.9	23.3	121.3	12.1	64.5	110.2
26		120	15×70	2437	3	42.6	1037	37.9	40.4	23.7	123.7	12.9	64.2	110.2
27		120	20×70	2585	1	40.6	1049	35.3	39.9	24.5	122.2	13.9	64.0	110.5
LSD (0.05)				425*		1.4	113**	3.2**	0.8**	2.1**	7.9**	0.9**	1.5**	1.0**
C.V. (%)				12.1		2.3	9.1	4.9	1.3	4.4	5.1	7.4	0.8	0.6

*, **: Significant at 0.05 and 0.01 levels.

Table 6: Maximum and economically optimal seed yields of three sunflower hybrids as calculated from regression equations as a response to fertilizer rates.

Nitrogen rate	DW-1 Y=1906.0+4.56 X–0.031 X^2 (R=0.778**)			DW-2 Y=1636.0+11.18 X– 0.064 X2 (R=0.857**)			Trakya-80 Y=2019.6+8.35 X – 0.042 X^2 (R=0.833**)		
	Total yield	Marginal yield	Value of marginal yield	Total yield	Marginal yield	Value of marginal yield	Total yield	Marginal yield	Value of marginal yield
(kg/ha)	(kg/ha)	(kg/da)	(TL/ha)	(kg/ha)	(kg/da)	(TL/ha)	(kg/ha)	(kg/da)	(TL/ha)
0	1906.0	0.0	0.00	1636.0	0.0	0.00	2019.6	0.0	0.00
10	1948.5	42.5	25.08	1741.4	105.4	62.18	2098.9	79.3	46.78
20	1984.8	36.3	21.42	1834.0	92.6	54.63	2232.3	70.9	41.83
30	2014.9	30.1	17.76	1913.8	79.8	47.08	2286.4	62.5	36.87
40	2038.8	23.9	14.10	1980.8	67.0	39.53	2332.1	54.1	31.91
50	2056.5	17.7	10.44	2035.0	54.2	31.97	2362.1	45.7	26.96
60	2068.0	11.5	6.78	2076.4	41.4	24.42	2369.4	37.3	22.00
70	2073.3	5.3	3.12	2105.0	28.6	16.87	2398.3	28.9	17.05
80	2072.4	-0.9	-0.53	2120.8	15.8	9.32	2418.8	20.5	12.09
90	2065.3	-7.1	-4.18	2123.8	3.0	1.77	2430.9	12.1	7.13
100	2052.0	-13.3	-7.85	2114.0	-9.8	-5.78	2434.6	3.7	2.18
110	2032.5	-19.5	-11.50	2091.4	-22.6	-13.33	2429.9	-4.7	-2.77
120	2006.8	- 25.7	-15.16	2056.0	-35.4	-20.88	2416.8	-13.1	-7.72.

*: 1 kg ammonium nitrate fertilizer price in 2001 in Turkey (%26 N): 0.22 TL
**: 1 kg oilseed sunflower price in 2001 in Turkey: 0.59 TL

CONCLUSIONS

Nitrogen fertilizer rates increased seed yield, oil content, oil yield, hull percentage and head diameter of three different-height sunflower hybrids in natural rainfed conditions significantly ($p \leq 0.01$ and $p \leq 0.05$). Regression equations for DW-1 ($Y=1906.0+4.56\,X–0.031\,X^2$), DW-2 ($Y=1636.0+11.18\,X – 0.064\,X^2$) and Trakya-80 ($Y=2019.6+8.35\,X–0.042\,X^2$) were found to be significant. Based on marginal economic analyses, the economically optimal seed yield per hectare was obtained at 50 kg N/ha for DW-1 and at 80 kg N/ha for DW-2 and Trakya-80.

In all three hybrids, increasing plant densities decreased 1000-seed weight, hull percentage, and head diameter but increased test weight in natural rainfed conditions.

As a result, the highest seed and oil yields under the rainfed conditions of Edirne in Turkey were produced by the two dwarf hybrids at 15 × 70 cm (95,230 plant/ha).

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