HELIA, **21**, Nr. 28, p.p. 107-116, (1998) UDC 631.53.04:633.854.78

EFFECT OF PLANTING DATE AND PLANT POPULATION ON SEED AND OIL YIELDS AND PLANT CHARACTERISTICS IN SUNFLOWER (*Helianthus annuus* L.)

Göksoy A.T.*, Turan Z.M., Açikgöz E.

Department of Field Crops, Faculty of Agriculture, Uludag University, Bursa 16059, Turkey

Received: July 28, 1997
Accepted: April 14, 1998

SUMMARY

This two-years study was conducted to determine the effects of planting date and plant population on seed yield, oil content and certain plant characteristics of sunflower under dryland conditions in the Marmara Region of Turkey. Three planting dates (March, April, May) were established with two hybrids (Sunbred-265 and H-1) and open pollinated cultivar (VNIIMK-8931) at three plant populations (30,000, 47,500 and 95,000 plants/ha).

Seed yield and yield components decreased significantly with later planting dates. The highest seed yield, 1000-seed weight, seed weight per head, oil content and oil yield were obtained when sunflowers were sown in mid-March or mid-April. Compared with mid-May, the plantings in mid-March and mid-April increased seed yield by about 41% and 34%, respectively. Number of days from planting to flowering (50%) decreased as planting dates were delayed. Plant population significantly affected seed and oil yields and other plant characteristics measured. As plant population increased, head diameter, 1000-seed weight, and seed weight per head decreased, but plant height increased. The highest seed yield, oil content and oil yield were obtained at 95.000 plants per ha.

Key words: ***Helianthus annuus* L., dryland sunflower production, sowing date, plant population.**

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is the most important oilseed crop in the Marmara Region of Turkey. Although the crop is grown at large areas (389,500 ha) information on cultural practices for sunflower production in this region is limited.

Planting time and plant population are the major factors influencing sunflower seed yield and its components (Robinson, 1970; Johnson and Jellum,1972). Highest seed yield and oil content were achieved with early plantings in the dry regions

of the Northern U.S. Plains (Robinson, 1970; Alessi *et al.*,1977; and Miller *et al.*,1984). Robinson (1970) reported that seed yield decreased when seed was planted after late May. In the North Central USA, Miller *et al.* (1984) recommended to plant sunflower early- and mid-May for highest seed yield, seed weight, seeds/head, oil percentage, and oil yield. Johnson and Jellum (1972) found that yields and oil percentage of sunflower were increased in Southeasthern United States when sunflower was planted between mid-March and late-April compared with later plantings. Unger (1980) reported that under irrigated conditions in Texas, seed yields were not significantly different with plantings from late-March to mid-June, but decreased with plantings after 21 June. In Canada, Putt (1967) found that early-May planting gave higher seed yield . The literature reports that optimum sunflower plant densities varied greatly in different regions (Robinson *et al.*,1980; Enns and Giesbrecht, 1971; Mian and Gaffer, 1971; Lopez,1972 and Vijayalakshmi *et al.*,1975). In Georgia, USA, increasing plant density from 20,000 to 60,000 plants per hectare significantly increased seed yield (Massey, 1971). In North Dakota, USA, Zubriski and Zimmerman (1974) reported that increasing the plant density from 36,000 to 72,000 plants/ha significantly increased seed and oil yields, reduced the head diameter, but had no significant effect on oil concentration. In Australia, Jessop (1977) found that the highest seed and oil yields were obtained from a plant density of 25,000 or 50,000 plants/ha. In North Dakota, USA, Miller and Fick (1978) and Prunty (1981) reported that seed yields were not affected by the plant population.

The main objective of this research was to determine the effects of planting date and plant population on seed yield, oil percentage and some important plant characteristics of sunflower under dryland conditions of Marmara Region in Turkey.

MATERIALS AND METHODS

Field trials were conducted during 1989 to 1990 on a clay loam soil at Uludad University Research Farm, Bursa. A split-split-plot design was used with four replications. Planting dates were main plots, cultivars subplots and plant populations sub subplots. Plantings were made on 14 March, 12 April, and 16 May in 1989; 20 March, 19 April, and 18 May in 1990. Two commercial hybrids (Sunbred-265, and H-1) and an open-pollinated variety (VNIIMK-8931) were planted at a rate of 30 kg/ha. Seedlings were thinned by hand at the second leaf stage to three different plant populations of 30,000, 47,500, and 95,000 plants/ha. These populations correspond to 70x45, 70x30, 70x15 cm row spacing, respectively. The size of the sub subplots in the experiment was 22.4 m^2 (8.0x2.8 m).

Sixty kg N/ha as ammonium nitrate was applied prior to sowing and a further 60 kg N/ha applied when the plants started budding. Before planting trifluralin was applied at a rate of 0.20 g/m^2 for weed control. Hand hoeing was done when necessary.

Twenty plants were randomly selected from each plot for plant height, head diameter, and seed weight/head measurements. Plots were harvested by hand and then threshed by plot harvester for seed yield and other seed characters. Oil percentage was determined by the nuclear magnetic resonance (NMR) technique (Granlund and Zimmerman, 1975) using kernels, i.e., without hull dried at 70°C, and then oil yield was calculated.

All data were subjected to analysis of variance for each trait. The significance of main effects and interactions was determined at the 0.05 and 0.01 levels by the F test. Bursa is located in the Marmara Region with average 700 mm annual rainfall. Total monthly precipitation and mean air temperature data are presented in Table 1. Soil analysis indicated that phosphorus and potassium levels were medium or high and organic matter was low (1.2 %). The soil pH was 7.4. The water logging problem is not present and water table into the soil is 100 cm below the soil surface in the early spring.

Table 1: Mean air temperature (°C) and total monthly precipitation in 1989 and 1990, and between 1928 and 1986 at Bursa

	Temperature (°C)			Precipitation (mm)		
Month	1989	1990	1928-86	1989	1990	1928-86
March	10	9	8	23	26	70
April	17	13	12	12	72	60
May	18	16	18	44	68	52
June	22	21	22	45	22	30
July	24	24	24	8	40	27
August	25	23	24	10	2	22
Total				142	230	261

RESULTS AND DISCUSSION

Large variations between years and treatment interactions made the results difficult to interpret. However significant differences for seed and oil yield and some yield components were found between years, planting dates, cultivars, plant populations and between the interactions of years x dates, years x cultivars, and years x plant populations. Planting date x plant population interaction significantly affected head diameter, seed weight/head, seed yield, oil percentage and oil yield. Plant height was not significantly influenced by the year and planting date x plant population interactions. Interactions between cultivars x plant populations cause significant differences in oil percentage, oil yield, and 1000-seed weight (Table 2).

The results clearly indicated that delaying the planting from mid-March to mid-May significantly reduced seed and oil yields and the other plant characters measured (Table 3). On average, the highest seed and oil yields were obtained when plantings were done in mid-March and mid-April. Plantings in mid-March and mid-April increased seed yield by about 41% and 34%, respectively, compared with mid-

Table 2: Results of variance analysis of seed yield, oil yield, oil percentage and some plant traits in three varieties of sunflower sown at different sowing dates and plant populations in 1989 and 1990

Source	df +	Plant height	Head diameter	Seed weight per head	1000- seed weight	Seed yield	Oil percentage	Oil yield
				Significance of F values				
Years (Y)	1	ns	**	**	**	**	**	**
Blocks	6	*	*	ns	ns	ns	ns	ns
Dates (D)	2	**	**	**	**	**	**	**
Y x D	2	**	**	**	**	**	**	**
Error a	12							
Cultivars (C)	2	**	**	**	**	**	**	**
Y x C	2	**	**	**	**	**	**	**
D x C	4	ns	ns	ns	**	ns	ns	ns
Y x D x C	4	*	ns	ns	ns	ns	ns	ns
Error b	36							
Plant Pop. (P)	2	**	**	**	**	**	**	**
Y x P	2	*	**	**	**	ns	ns	ns
D x P	4	ns	*	**	ns	**	*	**
Y x D x P	4	**	**	ns	*	ns	ns	ns
C x P	4	ns	ns	ns	**	ns	**	*
Y x C x P	4	**	ns	ns	ns	ns	ns	ns
D x C x P	8	ns	ns	ns	ns	ns	ns	ns
Y x D x C x P	8	*	ns	ns	ns	ns	ns	ns
Error c	108							

*,** Significant at the 5 and 1 % level, respectively.
+df = Degrees of freedom.
ns = Not significant.

Table 3: The effects of planting date and plant population on seed yield, oil percentage and oil yield and some plant characters at Bursa , Marmara Region, (Two-year Average)

Treatment	Plant height	Head diameter	Seed weight per head	Seed weight	Seed yield	Oil* percentage	Oil yield
	cm	cm	g	g / 1000	kg / ha	%	kg / ha
Date							
mid-March	148.5 a	17.1 a	55.5 a	53.4 a	2706 a	62.4 a	1208 a
mid-April	143.8 b	16.8 a	52.9 a	51.6 b	2576 a	61.8 b	1142 a
mid-May	133.9 c	16.1 b	40.1 b	43.8 c	1919 b	62.7 a	838 b
Cultivar							
Sunbred 265	129.9 c	16.9 a	50.8 a	49.9 b	2476 a	62.8 a	1097 a
H-1	136.6 b	17.2 a	49.8 ab	42.3 c	2414 a	62.6 a	1072 a
Vniimk 8931	159.7 a	15.9 b	48.0 b	56.5 a	2312 b	61.4 b	1019 b
Population (Plants/ha)							
30.000	137.2 c	19.5 a	71.7 a	56.5 a	2277 c	61.8 b	1003 c
47.500	142.7 b	16.9 b	50.4 b	49.8 b	2402 b	62.6 a	1071 b
95.000	146.3 a	13.6 c	26.5 c	42.5 c	2523 a	62.4 a	1114 a
L.S.D. 0.05							
Planting date	4.3	0.5	3.3	1.5	162	0.4	70.6
Population	1.9	0.3	2.0	1.1	83	0.4	42.0
Cultivar	2.6	0.3	1.9	1.0	95	0.5	41.9

* Oil percentage in the kernel.

May planting. The year x planting date interaction indicated that yield and yield components were not consistent over the years. As known, amount and distribution of the precipitation are the major factors affecting seed yield of sunflower in dry regions. The precipitation during the growing period of sunflower for long-term (1928-86) and 1989 and 1990 seasons was 261 mm, 142 mm and 230 mm, respectively in Bursa. The first year of the study was very dry with 119mm below average. In 1990, precipitation was 31 mm below normal but with favorable distribution (Table 1). The significant year x planting date interactions for seed weight per head and seed yield indicated that mid-March and mid-April plantings produced higher seed weight/head and seed yields than mid-May planting in wet years. Whereas these two characters were not affected by delayed plantings in dry years. The results obtained from mid-March and mid-April plantings in the drought-prone Marmara Region of Turkey are consistent with those reports in the dry regions of Southern Great Plains and the Northern US Plains (Robinson, 1970; Alessi *et al.*, 1977; Owen, 1983; Miller *et al.*, 1984). Early planting maximized plant height, head diameter, 1000-seed weight, and seed weight/head as well as seed yield and oil yield.

Sunflower seed and oil yields and the other plant characteristic were significantly influenced by plant population (Table 2). Increased plant population reduced head diameter, 1000-seed weight and seed weight/head, but seed yield, oil percentage, oil yield and plant height significantly increased as population increased from 30.000 to 95.000 plants/ha. Over the two-years, the highest average seed and oil yield and plant height were produced by the population of 95,000 plants/ha, whereas the highest head diameter, 1000-seed weight, and seeds weight/head were obtained from the population of 30,000 plants/ha. Also, the highest seed oil contents were obtained from the populations of 47,500 and 95,000 plants/ha (Table 3). In close agreement with our findings, Robinson *et al.* (1967), Massey (1971) and Zubriski and Zimmerman (1974) reported that the seed yield, oil yield and plant height increased and that the head diameter and weight/seed decreased with higher plant populations.

The planting date x plant population interaction was significant in seed yield, oil percentage, oil yield, head diameter and seed weight/head (Table 2). The seed and oil yields in the early plantings were significantly increased as population increased from 30.000 to 95.000 plants/ha, but they were not influenced by the plant population in the late planting, due to insufficient precipitation. The significant planting date x plant population interaction for seed weight per head indicated that reduction in seed weight per head with plant populations ranging from 30.000 to 95.000 plants/ha declined with delayed plantings. These results showed that seed and oil yields and seed weight per head were affected by plant population in early plantings. Contrary to that, they were not greatly influenced by plant population under unfavorable environmental conditions of late planting. The highest oil percentages were obtained from mid-May planting with 47,500 and 95,000 plants/ha. Signifi-

cant cultivar x plant population interactions on oil percentage, oil yield, and 1000-seed weight indicated that the cultivars responded differently to different plant populations. For example the oil yield of Sunbred-265 was significantly higher than those of the other cultivars at 95,000 plants/ha, but differences between cultivars were not significant at 30,000 and 47,500 plants/ha.

Hybrids (Sunbred-265 and H-1) produced significantly higher seed yield, oil percentage, oil yield, head diameter, and seed weight/head than the open-pollinated cultivar (VNIIMK-8931). Plant height and 1000-seed weight of VNIIMK-8931 were significantly higher than those of the hybrids (Table 3).

CONCLUSION

Over the two-year period in the dry Marmara Region of Turkey, plantings of sunflower in mid-March to mid-April produced higher yields than the mid-May planting. The highest seed yield, oil percentage, oil yield, and plant height were obtained from the population of 95,000 plants/ha. Hybrid cultivars produced significantly higher seed and oil yields, oil percentage, head diameter, seed weight/head than the open-pollinated VNIIMK-8931.

ACKNOWLEDGEMENTS

The authors wish to thank Dr. K.E. Milligan, Lincoln Int. Ltd. and Dr. H.J. Braun, CIMMYT, Ankara for critical reading of the manuscript.

REFERENCES

Alessi, J., Power, J.F. and Zimmerman, D.C., 1977. Sunflower yield and water use as influenced by planting date, population, and row spacing. Agron. J. 69, 465-469.

Enns, H. and Giesbrecht, J.E., 1971. Spacing of sunflowers, soybeans, and corn. Can. Dep. Agric. Canadex 140. 20.

Granlund, M. and Zimmerman, D.C., 1975. Effect of drying conditions on oil content of sunflower (*Helianthus annuus* L.) seed as determined by wide-line nuclear magnetic resonance (NMR). Proc. N. Dak. Acad. Sci. 27, 128-132.

Jessop, R.S. 1977. Influence of time of sowing and plant density on the yield and oil content of dryland sunflowers. Australian J. Exp. Agric. and Animal Husb. 17, 664-668.

Johnson, B.J., and Jellum, M.D., 1972. Effect of planting date on sunflower yield, oil and plant characteristics. Agron. J. 64, 747-748.

Lopez, M., 1972. Effect of date of planting and the row spacing on sunflower crop in the Andalucia (Southern Spain). Proceedings of the Fifth International Conference on Sunflower, Clermont-Ferrand, France, p.133.

Massey, J.H., 1971. Effect of nitrogen rates and plant spacing on sunflower seed yields and other characteristics. Agron. J. 63, 137-138.

Mian, A.L. and Gaffer, M.A., 1971. Effect of size of plant population and level of fertilization on the seed yield of sunflower. Science and Industry 8, 264.

Miller, J.F. and Fick, G.N., 1978. Influence of plant population on performance of sunflower hybrids. Can. J. Plant Sci. 58, 597-600.

Miller, J.F., Oplinger, R., Rand, R., Peters, J. and Weis, G., 1984. Effect of planting date and plant population on sunflower performance. Agron. J. 76, 511-515.

Owen, D.F., 1983. Differantial response of sunflower hybrids to planting date. Agron. J. 75, 259-262.

Prunty, L., 1981. Sunflower cultivar performance as influenced by soil water and plant population. Agron. J. 73, 257-260.

Putt, E. D., 1967. Sunflower seed production. Can. Dep. Agr. Pub. 1019.

Robinson, R. G., 1970. Sunflower date of planting and chemical composition at various growth stages.Agron. J. 62,665-666.

Robinson, R.G., Johnson, F.K. and Soine, O.C. 1967. The sunflower crop in Minnesota. Minn. Ext. Bull. 299.

Robinson, R.G., Ford, J.H., Lueschen, W.E., Rabas, D.L., Smith, L.J., Warnes, D.D. and Wiersma, J.V., 1980., Response of sunflower to plant population. Agron. J. 72, 869-871.

Unger, P.W., 1980. Planting date effects on growth, yield and oil of irrigated sunflower. Agron. J. 72, 914-916.

Vijayalakshmi, K., Sanghi, N.K., Pelton, W.L. and Anderson, C.H., 1975. Effects of plant population and row spacing on sunflower agronomy. Can. J. Plant Sci. 55, 491-499.

Zubriski, J.C. and Zimmerman, D.C., 1974. Effects of nitrogen, phosphorus and plant density on sunflower. Agron. J. 66, 798-801.

EFECTOS EN EL GIRASOL (*Helianthus annuus* L.) DE LA FECHA DE SIEMBRA Y DE LA POBLACIÓN DE PLANTAS EN LA PRODUCCIÓN DE SEMILLAS Y DE ACEITE Y EN LAS CARACTERÍSTICAS DE LA PLANTA

RESUMEN

Este estudio de dos años se llevó a cabo con el fin de determinar los efectos en el girasol de las fechas de siembra y de la poblacion de plantas en la producción de semillas, el contenido oléico y ciertas características de la planta en condiciones de secano en la región Marmara de Turquía. Se establecieron tres fechas de siembra (Marzo, Abril y Mayo) con dos híbridos (Sunbred-265 y H1) y un cultivar de polinización libre (VNIIMK-8931) con poblaciones de 3 plantas (30000, 47500 y 95000 plantas/ha).

La producción de semillas y los componentes de producción bajaron de manera significativa con fechas de siembra más tardías. Se obtuvieron la producción de semillas, el peso por 1000 semillas, el peso de semillas por capítulo, el contenido oléico y la producción oléica más elevados cuando se sembró el girasol a mediados de Marzo o de Abril. En comparación con la de mediados de Mayo, en las siembras efectuadas a mediados de Marzo o de Abril hubo un aumento de la producción de semillas de aproximadamente 41% y 34%, respectivamente. El número de días desde la siembra hasta la floración (50%) disminuyó a medida que se retrasaron las fechas de siembra. La población de las plantas afectó de manera significativa la producción de semillas y de aceite y otras características de la planta que se midieron. A medida que la población de plantas aumentó, el diámetro del capítulo, el peso de 1000 semillas y el peso de las semillas por capítulo disminuyeron pero la altura de la planta aumentó. Se obtuvieron la producción de semillas, el contenido y la producción de oléico más elevados con 95000 plantas/ha.

EFFET DE LA DATE DE SEMIS ET DU PEUPLEMENT SUR LE RENDEMENT EN GRAINS ET EN HUILE ET LES CARACTÉRISTIQUES DU TOURNESOL (*Helianthus annuus* L.)

RÉSUMÉ

Cette étude d'une durée de deux ans a été conduite pour déterminer les effets des dates de semis et de peuplement sur le rendement en grains, la teneur en huile et certaines autres caractéristiques du tournesol, dans les conditions sèches de la région de Marmara en Turquie. Trois dates de semis (Mars, Avril, Mai) ont été effectuées avec deux hybrides (Sunbred-265 et H-1) et une variété population (VNIIMK-8931) à trois densités de peuplement (30000, 47500 et 95000 plantes/ha).

Le rendement en grains et les composantes du rendement diminuent significativement avec les dates de semis tardives. Le rendement le plus élevé, le poids de 1000 grains, le poids de grain par capitule, la teneur en huile, le rendement en huile, sont atteints par les semis de mi-Mars ou de la mi-Avril. Comparés au semis de la mi-Mai, les semis de mi-Mars et mi-Avril conduisent respectivement à des augmentations de rendement d'environ 41% et 34%. Le nombre de jours séparant le semis de 50% de floraison diminue lorsque les dates de semis sont retardées. Le peuplement influence significativement les rendements en grains et en huile et les autres caractéristiques mesurées. Lorsque le peuplement augmente, le diamètre du capitule, le poids de 1000 grains et le poids de grains par capitule diminuent alors que la taille s'accroît. Le rendement en grains, la teneur en huile et le rendement en huile les plus forts sont obtenus à 95000 pieds/ha.