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Full Length Research Paper

Effects of drought stress and different densities on oil yield and biomass yield of sunflower varieties

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For evaluation of water deficit stress and planting density effects on the oil and biological yield attributes of sunflower, an experiment was conducted in a randomized complete block design (RCBD) based split plot factorial design in three replications in the research field of Baku State University, Baku, Azerbaijan, in 2009. The factors studied were irrigation (with 70, 140 and 210 mm water evaporation from the evaporation pan), planting densities (with 10, 20 and 30 plant/m^2) and four sunflower cultivars (airfloure, alestar, armawirski and Ismailli). The results showed that the application of water deficit stress decreased plant height, seed number per head, oil percentage, oil yield, biomass yield, seed yield, thousand seed weight and other related traits significantly. Means compression showed that the highest oil and grain yield, biological yield and the highest number of plant were achieved in 20 plant/m^2. In water application after 70 mm evaporation from Class A pan, airfloure and alestar cultivars had the highest seed number per head and the least hollowness percent, while the maximum biological yield was seen in airfloure cultivar in the consumption of 20 plant/m^2 and water application after 210 mm evaporation from Class A pan. However, the highest seed yield was obtained at 20 cm density, and airfloure yielded higher than alestar cv.

Key words: Sunflower, density, seed yield and biomass yield, drought stress.

INTRODUCTOIN

The Aegean and Azerbaijan region, having favorable ecological conditions and winter rainfall resources, provides proper growth conditions for many different varieties of field crops production. Therefore, crop cultivation can be maintained by benefiting from different types of technical facilities throughout the year. As a major example, the second forage crop cultivation includes corn, sorghum, etc (Cellier et al., 1998). Particularly, the second oil crop production of vetch and vetch-barley mixtures in winter are generally preferred by farmers considering the low inputs of cultivation in Aegean region. Low irrigation is one of the methods of agricultural productions when there is deficiency in the availability of water (Afkari, 2010; Hallaji, 2004). Seed size is an important seed quality characteristic affected by variety, environment and management practices (Afkari, 2010). The influence of seed size on crop establishment has been studied extensively. Generally, decreasing seed size reduced the seedling establishment (Damirkaya et al., 2006) and claimed an increase in the number of hollow and green seeds as a result of undesirable pollination of blooms (Afkari, 2010; Ahmadi, 2006). Sunflower (*Helianthus annuus* L.) is a promising new alternative for the winter second crop in these areas. It is being used in a wide range of climatic regions, and this illustrates its adaptability to climate and soil types (Gubbels and Dedio, 1999). The plant is herbaceous and non-leguminous, and it flowers annually in the Hydrophy llaceae family (Forbes and Watson, 1992). Autumn and spring planted *Phacelia* flowers are applied 6 to 8 weeks after germination and flowering continues for 6 to 8 weeks (Munz, 1973). Researches in other regions show that *Phacelia tanacaetifolia* has the potential to produce abundant biomass and does a good job at catching excess nitrate. Its use as a fall/winter cover crop may be appropriate when it is followed by a vigorous cash crop (for example, cotton and maize) in early spring. More-over, Europe has developed many varieties.

The fact that Europeans imported the US native plant and breed it for specific characteristics indicates its value in a crop rotation system (Orsi and Biondi, 1987; Williams and Christian, 1991). The reduced leaf number and area lead to a low level of photosynthesis and photosynthetic production and consequently, to a lower plant production

Table 1. Biometrics of sunflower varieties affected by row spacings in Baku.

Raw spacing (cm)/cultivar	Grain number per head	Plant height (cm)	Oil percentage (%)	Biomass yield (kg/ha)	Oil yield (kg/ha)	Grain yield (kg/ha)	1000 seed weight (g)
10	767^{c}	162^{c}	38^{c}	33234^{a}	1642^{c}	2786^{c}	48^{c}
15	831^{b}	174^{b}	42^{b}	26726^{b}	1813^{b}	3637^{b}	51^{b}
20	912^{a}	192^{a}	47^{a}	14562^{c}	2102^{a}	4251^{a}	56^{a}
Mean	836.67	176	42.33	24840.66	1852.33	3558	51.67
LSD	13.7	15.71	12.47	17.61	16.17	13.24	15.72
Armawireski	785^{c}	199^{a}	46^{c}	32477^{a}	2123^{c}	4158^{bc}	61^{c}
Alestar	673^{d}	156^{d}	41^{d}	11426^{d}	1628^{d}	3019^{d}	50^{d}
Airfloure	924^{a}	167^{c}	57^{a}	15683^{c}	2759^{a}	4324^{b}	69^{a}
Ismailli	863^{b}	171^{b}	54^{b}	24634^{b}	2423^{b}	5436^{a}	68^{ab}
Mean	811.25	173.25	49.5	21055	2233.25	4234.25	62
LSD	13.41	14.93	14.24	16.02	17.43	14.81	13.42

Different letters in columns show significant difference based on Duncan's multiple range test at $P < 0.01$.

and biomass (Afkari et al., 2009). More information is needed about this potentially useful plant and how to cultivate it in Azerbaijan basin. Seed production technique of sunflower is also of primary significance. In this study, four sunflower varieties in three different densities under rain-fed conditions were tested for seed yield and some other related traits for years.

MATERIALS AND METHODS

A field study was conducted in the 2009 spring growing season in the experimental area of Baku University, Baku, Azerbaijan. The soil textural class of the experimental field was sandy loam; while other soil characteristics were as follows: pH (8.2), available potassium of 186 ppm, available phosphorus of 5 to 6 ppm, total nitrogen of 0.60% and organic carbon of 1.05%. The research field was located in a semiarid region, where the summer is hot and dry and the winter is cool and rainy. Trials were arranged as a split plot factorial experiment with randomized complete block (RCB) design in three replications. The main plots were allocated to irrigation intervals [irrigation after 70 (S_0), 140 (S_1) and 210 (S_2) mm evaporation from Class-A pan], while the sub-plots were assigned to sunflower cultivars [airflour (v_0), ismailli (v_1), armawirski (v_2) and alestar (v_3)]. Each subplot was 24 m^2 and it consisted of six rows. It was 6 m long and it was located 50 cm apart. All sub plots were fertilized with the same amount of fertilizer. Water deficit stress treatment and a combination of two other treatments were arranged in the main and sub plots, respectively. Factorial arrangements of three density (D_0 = 10, D_1 = 15 and D_2 = 20 cm) were evaluated in a randomized complete block design with three replications. Herbicide was not applied for weed control, instead hand-hoeing was carried out when necessary. NPK fertilization of 70 kg ha^{-1} before sowing and 70 kg ha^{-1} days after planting (DAP) in early spring was uniformly applied to all plots. Thus, there were no significant problems with pests, diseases or weeds during the course of the study. Randomly, ten plants from each replication were taken at semi maturity stage of racemes for morphological measurements. Plant heights, number of plant branches, number of terminal flowers per plant, number of racemes per plant and number of florets per raceme, biomass plant, seed yields and thousand seed weight were investigated individually. Statistical analysis of the collected data was done using SAS and MSTATC software with mean comparison by least significant difference test (LSD) in the 5 and 1% probability levels.

RESULTS AND DISCUSSION

Density and varietal interactions for all the traits were not significant except for seed yield. Therefore, density and variety treatments were evaluated independently. The results are summarized in Table 1. The experimental area is located in the Mediterranean zone of the country with relatively mild winters and hot summers. Field studies commenced in late autumn with low air temperature and the satisfactory moisture levels were experienced in the germination and emergence period of relatively small seeds. Therefore, stands were excellent in years.

Plant height

Sunflower plant height increased with the increasing rate of density (Table 1). Density of 10 cm had the highest average plant height, whereas plant height was lowest in 20 cm density. However, there was no significant difference between varieties (Figure 3). The study's results are in agreement with the results reported by Tworkowski et al. (1999).

Grain and oil yield

Sunflower yield had a close correlation with the number of flowers in the species, which means that with high number of flowers, the spaces will be thicker and the

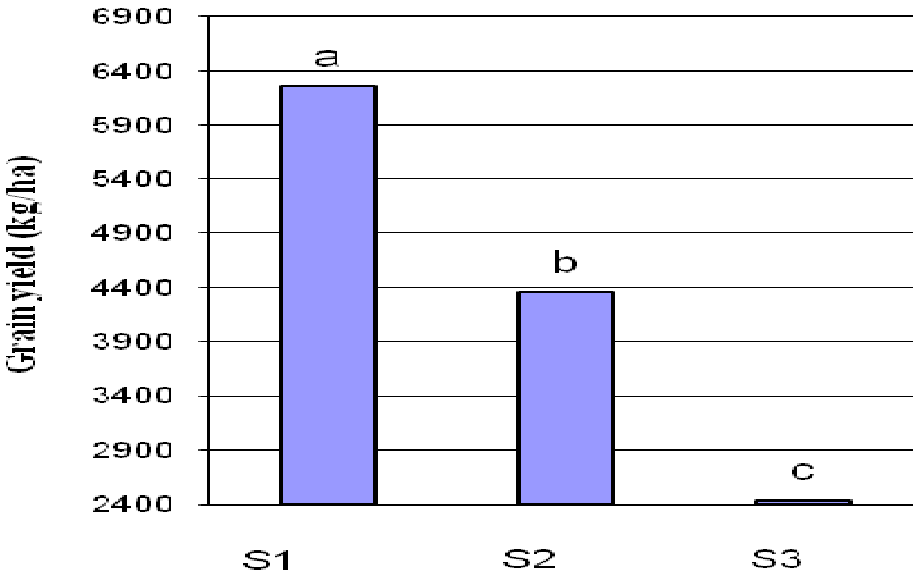

Figure 1. Changes in grain yield under different irrigation levels.

accumulation will be more successful. Consequently, grain yield will be higher and parallel with the spaces. The factors like non-fertilization of flowers, temperature, relative water content, environment, soil humidity, lack of nutrition and insects for pollination result in grain hollowness. Cultivars and water application rates had significant interaction (Figures 1 and 2). However, the maximum hollowness in ismailli cultivar was 5.02%. Likewise, the maximum hollowness of airfloure cultivar was 3.84% and its minimum was 1.89% in 210 and 70 mm evaporation from Class A pan, respectively, which shows significant differences in the reactions to water deficits. On the basis of the results, it can be concluded that water deficit exertion decreased the number of seed spices and sometimes increased and decreased their full seeds and hollowness percent, respectively. In 140 mm evaporation, the photosynthesis rate was higher than a decrease in the number of grain. Consequently, the percent of grain hollowness increased. Nonetheless, the maximum harvest index was 33.44% in airflour cultivar in 70 mm evaporation. Plant adjustment against water deficit condition or its environment in reducing its growth period was the reason for the maximum harvest index in this level of water deficit. Similarly, there was a decrease in the plants reproductive organs size so that it could reach the blooming stage where the seeds are filled quickly and there was a decrease in the proportion of the shoot to seed number or reproductive parts in order to get higher harvest index. In other words, the effect of water deficit on biomass yield was lower than its effect on biomass yield (Figure 5) (Khalilvand and Yarnia, 2007).

The interactions of cultivars with potassium application amounts also led to a significant difference in the yield index. The maximum yield index was 41.07 in armawirski cultivar with 150 kg/ha potassium consumption, while its least yield index was 29.08 in alestar cultivar without potassium consumption. Alestar cultivar had the highest harvest index due to the low seedling height accompanied with an increase in potassium consumption, whereas the highest yield index was obtained in armawirski cultivar because of the higher seedling height without potassium consumption (Daulay and Sing, 1983).

The interaction of irrigation x cultivar was significant for oil yields ($p < 0.01$), but was also significant for oil yield and oil percentage (Figure 6).

Grain number per head

The analysis of data obtained from the measurement of seed number per head in different levels of water deficit stress showed significant differences at the probability level of 1%. The interaction of the fertilizer amounts and stress levels also resulted in a significant difference at the 5% probability level. Comparison of averages obtained from the effects of water stress levels on seed number per head showed a significant difference. The maximum number of seeds in the species was 988.7 and the least was 634.4 in 210 and 70 mm treatment evaporation from Class A pan, respectively (Table 1).

Thousand seed weight

The seed weight is an important and efficient component in plant yield. The factor which causes changes in thousand seed weight is the potential number of flowers which is determined during the plant growth period,

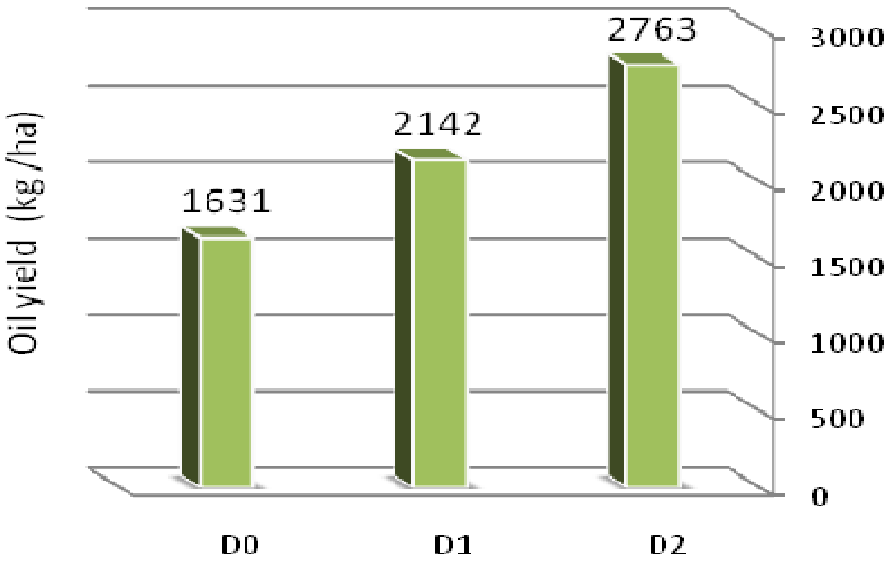

Figure 2. Changes in oil yield under different density levels.

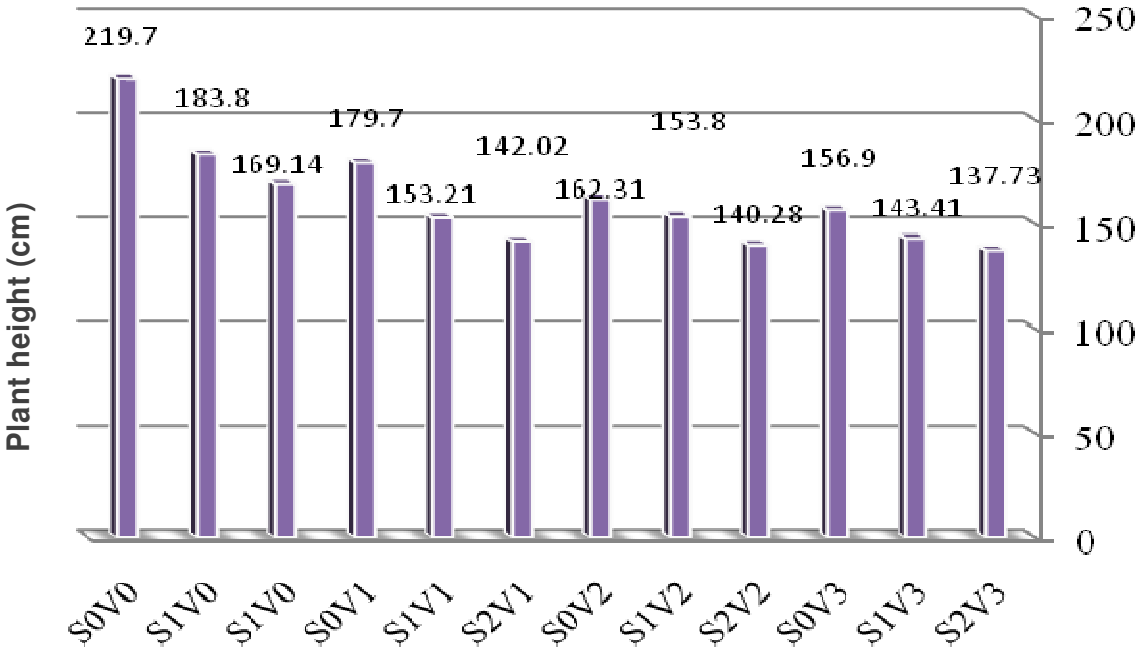

Figure 3. Effects of sunflower varieties and water deficit on plant height. Sunflower cultivars: Airflour (v_0), Ismailli (v_1), armawirski (v_2) and alestar (v_3). Irrigation levels: 70 (S_0), 140 (S_1) and 210 (S_2) mm evaporation.

particularly by leaf distribution (Jonson, 2003; Lio et al., 2004). The analysis of the data obtained from the measurement of thousand seed weight in different levels of water deficit stress showed significant differences at the probability level of 1%. The interaction of the fertilizer amounts and stress levels also resulted in a significant difference at the 5% probability level. Comparison of averages obtained from the effects of water stress levels on thousand seed weight showed a significant difference. The maximum weight of seeds in the species was 69.51 and the least was 50.29 in 210 and 70 mm treatment evaporation from Class A pan, respectively (Figure 4). The probability of sunflower nectar sweetness enhancement in low water stress and consequently, the

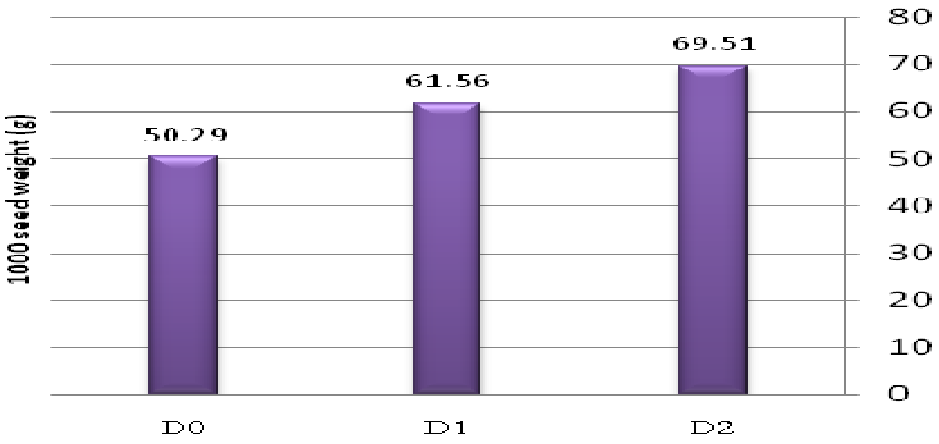

Figure 4. Changes in the one thousand seed weight under different density levels.

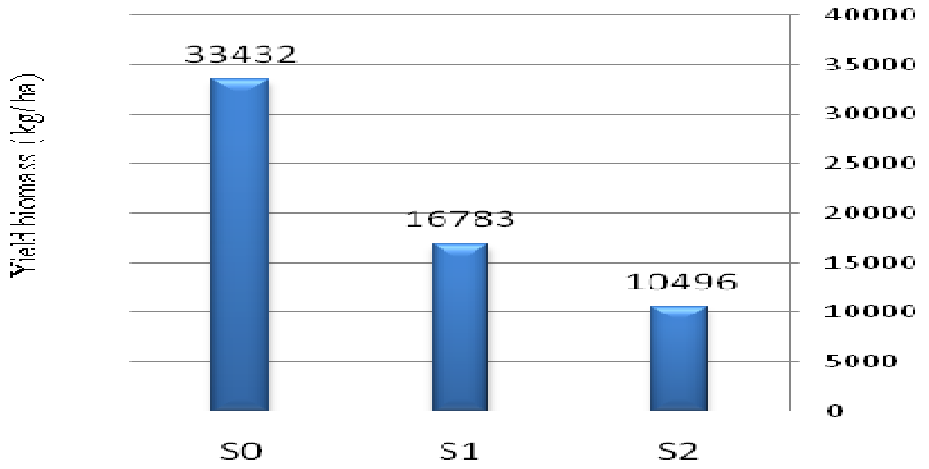

Figure 5. Changes in biomass yield under different irrigation levels.

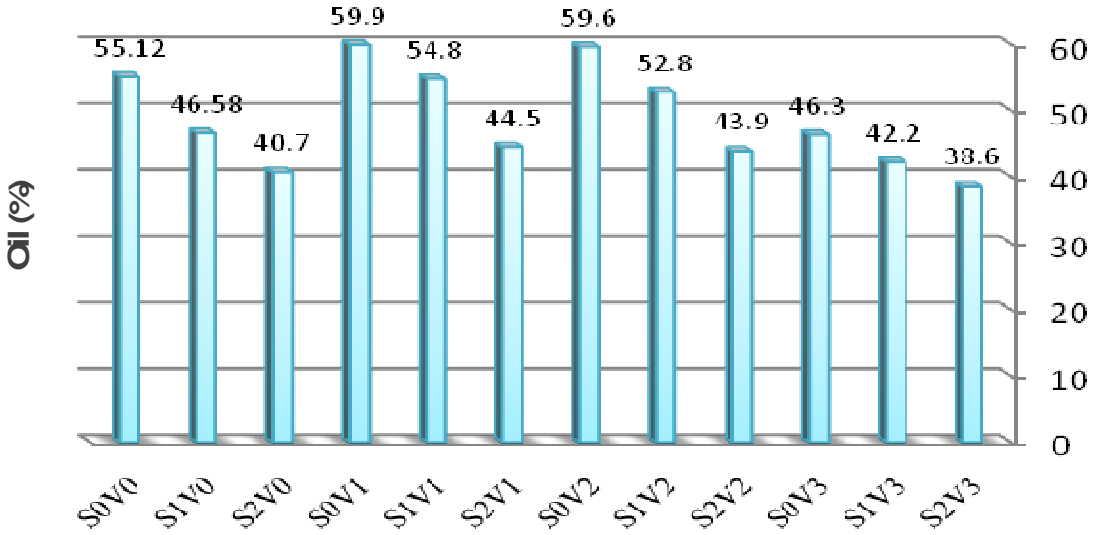

Figure 6. Effects of sunflower varieties and water deficit on oil percent. Sunflower cultivars: Airflour (v_0), ismailli (v_1), armawirski (v_2) and alestar (v_3). Irrigation levels: 70 (S_0), 140 (S_1) and 210 (S_2) mm evaporation.

attraction of more insects was the reason for the higher seed number per head in 210 mm evaporation.

REFERENCES

Afkari BA, Qasimov N, Yarnia M (2009). Effects of drought stress and potassium on some of the physiological and morphological traits of Sunflower (*Helianthus annuus* L.) cultivars. J. Food Agric. Environ. 7(3-4): 448-451.

Afkari BA (2010). Effect of water limitation on grain yield and oil yield of Sunflower (*Helianthus annuus* L.) cultivars. Agria. J. Food, Agric. Environ. 8(1): 132-135.

Afkari BA (2010). The effects of Nacl priming on salt tolerance in sunflower germination and seedling grown under salinity conditions. Afr. J. Biotechnol. 9(12): 1764-1770.

Ahmadi A (2006). An Introduction on Planting Physiology [P]. The Publication of Tehran University, pp. 79-95.

Cellier F, Conejero G, Breitler GC, Casse F (1998). Molecular and physiological responses to water deficit in drought-tolerant and drought sensitive lines of sunflower. Plant Physiol. 116: 319-328.

Damirkaya M, Okgu G, Atak GY, Kolsarici O (2006). Seed treatments to overcome salt and drought stress during germination in Sunflower (*Helianthus annuus* L.). Eur. J. Agron. 24: 291-295.

Daulay HS, Sing C (1983). A note on the effect of soil moisture stress of different growth stages of Sunflower. Ann. Arid Zone, 22(2): 169-172.

Forbes JC, Watson RD (1992). Plants in Agriculture. Cambridge University Press, p. 355.

Gubbels GH, Dedio W (1999). Response of sunflower hybrids to row spacing. Can. J. Plant Sci. 68(4): 1125-1127.

Hallaji H (2004). The Impacts of Water Deficit Stress and Density on Yield and Yield Components Hybrid of Azarghol Sunflower [P]. Islamic Azad University, Brujerd Branch, p. 122.

Jonson BL (2003). Dwarf sunflower response to row spacing, stand reduction and defolation at growth stages. Plant Sci. 83: 319-329.

Khalilvand B, Yarnia M (2007). The effects of water deficit stress on some of the physiological characters of sunflower in the different density of planting [P]. J. Agric. Sci. Islamic Azad University, Tabriz Branch, 1(2): 37-52.

Lio HS, Feng ML, Hao X (2004). Deficiency of water can enhance root respiration rate of drought- sensitive but not drought tolerant spring wheat. Agric. Water Manage. 64: 41-48.

Munz AP (1973). A California Flora. University of California Press, Berkley and Los Angeles.

Orsi S, Biondi A (1987). *Phacelia tanacetifolia*: It's honey potential. Informatore-Agrario, 43: 53-57.

SAS Institute (1990). SAS Users Guide: Statistics. Version 6. SAS Inst., Cary, NC.

Tworkowski J, Szczukowski S, Kwiatkowski J (1999). Yield and quality of *Phacelia tanacaetifolia* Benth. seeds depending on selected agrotechnical factors. Section of Agric., Forestry Veterinary Sci. Polish Academy Sci. 468: 241-247.

Williams IH, Christian DG (1991). Observation on *Phacelia tanacetifolia* Bentham (Hydropyllaceae) as a food plant for honey bees and bumble bees. J. Apic. Res. 30(1): 3-12.