

NOTE

**SUNFLOWER SUMMER-PLANTING YIELD AS
AFFECTED BY PLANT POPULATION AND
NITROGEN APPLICATION RATES**

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(Received: March 8, 1999)

ABSTRACT

Two similar experiments were conducted at two Agricultural Experiment Stations (Bajgah and Kushkak), Shiraz University, Shiraz, I.R.Iran in 1995 to evaluate the effects of plant population and N application rates on yield and yield components of a semidwarf hybrid of sunflower (*Helianthus annuus* L. c.v. Mehr) as summer planting. Both experiments were conducted as split plot arranged in a randomized complete block design with 4 replications. The seeds were drilled in sub-plots at row distances of 60 cm apart and 15, 25 and 35 cm between plants within rows. Nitrogen fertilizer was applied at 0, 23, 46, 69 and 92 kg N ha⁻¹ as urea in main plots. Increasing plant population decreased head diameter, seed number and weight per plant and seed protein percentages at both locations. Seed and oil yields increased with increasing plant population and reached a maximum at a population of 6.66 plants m⁻² (25 cm between plants in row) at both locations. Head diameter, seed number and weight per plant and seed and oil yields increased with increasing N application at both locations. In general, head diameter, seed and oil yields were higher at Bajgah where favorable conditions for crop growth and seed filling prevailed. The optimum plant population and N rate were 6.66 plants m⁻² and 69 kg N ha⁻¹ for both locations.

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Key words: Sunflower, Plant population, Nitrogen rates, Head diameter, Seed and oil yields.

NOTE

تحقیقات کشاورزی ایران

(۱۳۷۹) ۷۲-۶۲-۱۹

تأثیر تراکم بوته و میزان کود ازته بر عملکرد آفتابگردان در کشت تابستانه

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چکیده

برای ارزیابی تأثیر تراکم بوته و میزان کود ازته بر عملکرد و اجزای آن در یک هیبرید نیمه پا کوتاه آفتابگردان (*Helianthus annuus L.*) رقم مهر در کشت تابستانه دو آزمایش مشابه در سال ۱۳۷۴ در دو مزرعه آزمایشی دانشکده کشاورزی دانشگاه شیراز (باجگاه و کوشک) انجام شد. هر دو آزمایش به شکل کرت های خرد شده در قالب بلوک های کامل تصادفی با ۴ تکرار بودند. بذرها در کرت های فرعی به فواصل ردیف ۶۰ سانتیمتر و بوته روی ردیف ۲۵، ۱۵، ۲۵ و ۳۵ سانتیمتر کشت شدند. کود ازته به میزان های ۰، ۲۳، ۴۶، ۶۹ و ۹۲ کیلوگرم در هکتار ازت خالص بصورت اوره به کرت های اصلی اضافه شدند. با افزایش تراکم بوته قطر طبق، تعداد دانه ها و وزن آن ها در هر بوته و درصد پروتئین دانه در هر دو محل کاهش یافتند. عملکردهای دانه و روغن با افزایش تراکم بوته در هر دو محل افزایش یافتند و در تراکم ۶/۶۶ بوته در متر مربع (فاصله بوته روی ردیف ۲۵ سانتیمتر) حداکثر شد. با افزایش کود ازته قطر طبق، تعداد و وزن دانه در هر بوته و عملکردهای دانه و روغن در هر دو محل افزایش یافتند. بطور کلی، قطر طبق و عملکردهای دانه و روغن در باجگاه به علت مساعدتر بودن شرایط در طول دروه رشد گیاه و دوره پر شدن دانه بیشتر بود. تراکم بوته و میزان کود ازته بهینه در هر دو محل، به ترتیب ۶/۶۶ بوته در متر مربع همراه با ۶۹ کیلوگرم ازت بودند.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a major oilseed crop in Iran with an acreage of nearly 100,000 ha. Some oilseed sunflower hybrids have been recently developed in the country which are adaptable for mechanized farming, but few researches have been conducted on these new semidwarf hybrids. Previous investigations have been mostly carried out as yield trials of hybrid and nonhybrid cultivars (7, 8).

Increasing sunflower population, generally, increases the seed yields to a certain level. Optimum population depends on cultivar, environmental and field management factors (15, 20). Gubbels and Deidio (6) reported that a population of 4.5 plants m^{-2} was optimum for Saturn, Modern 12, CMH 103 and MF 707 cultivars. In another experiment (7) they also showed that seed oil percentages increased, but seed weight decreased with increasing population in MRS 34 and Sunwheat 101 cultivars and the optimum population was 6.0 plants m^{-2} for Sun M₂₀ and S₉₄ cultivars. Narwal and Malik (11) found that 5.5 plants m^{-2} was optimum for EC 9874 cultivar. They also showed that increasing population significantly increased unfilled seed and decreased seed oil percentages. Vijaylakshimi *et al.* (17) and Villalobos *et al.* (18) found population of 5.7 for Armaveric and more than 15.0 plants m^{-2} for SW 101 cultivars, respectively. However, Robinson *et al.* (15) reported that higher population did not decrease the yield of USDA 894, 860 and 923 cultivars and Radford (14) obtained populations ranging 5.0 to 10.0 plants m^{-2} for irrigated sunflower. Wade and Forman (19) also showed a higher optimum population for semidwarf hybrids.

Nitrogen fertilizers usually increase seed and protein yields of sunflower, but seed oil percentages decreases. Oil yields will usually increase up to a certain level of nitrogen. Blamey and Chapman (3) reported that N rates increased seed and oil yields and decreased oil percentages. They also found a negative correlation between oil and protein percentages. Zubriski and Zimmerman (21) also observed a decrease in seed oil percentages with N application. Sinswat and Steer (16) showed an increase in head weight with increasing N rates for Hysun 33 hybrid. The aim of the

present experiment was to evaluate the influences of plant population and N rates on yield and yield components of a semidwarf sunflower hybrid as summer-planting at two locations in Shiraz.

MATERIALS AND METHODS

Two experiments were conducted at two Agricultural Experiment Stations, College of Agriculture, Shiraz University located at Bajgah (52° 46'E, 29° 50' N, altitude: 1810 m), 20 km north and Kushkak (52° 46'E, 29° 50' N, altitude: 1650 m), 70 km northwest of Shiraz (Table 1). Soil properties and field management factors (15, 20). (Gibbels and Dierick (6) reported that Table 1. Mean monthly temperatures (growing season) and some soil properties of Bajgah and Kushkak Agricultural Experiment Station.

	Bajgah temperatures (°C)	Kushkak temperatures (°C)
Months		
June-July	23.7	24.0
July-August	23.7	24.9
August-September	20.7	23.0
September-October	19.4	18.6
Soil properties:		
N (%)	0.17	0.11
P (mg kg ⁻¹)	21.5	16.0
K (mg kg ⁻¹)	400.0	360.0
EC (ds m ⁻¹)	0.6	0.5
pH	8.00	8.15
Soil	Daneshkadeh (fine, mesic, Typic Calcixerepts)	Ramjerd (fine, mixed mesic, Typic Calcixerepts)

samples were taken up to 30 cm depth at four sites of each location and then mixed. The experimental sites were under wheat (*Triticum aestivum* L.) cultivation. Nitrogen, phosphorus, and potassium in both soils were determined by Kjeldahl (4), Olsen (12) and extraction with ammonium acetate (13) methods, respectively. The crops were harvested in June 1995, the residues were removed and the lands were prepared for sunflower plantings few days before sowing. Land preparation consisted of relatively

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deep tillage, disking twice at right angle with each other, and furrows establishment.

Experiments were conducted as a split-plot design arranged in randomized complete block with 4 replications at both locations. Plots were 6 rows of 8 m long. Nitrogen fertilizers was applied in main plots at rates of 0, 23, 46, 69 and 92 kg ha⁻¹ as N, one half at planting and the other half 40 d after planting, when the plants were at the bud stage. The seeds of a semidwarf sunflower oilseed hybrid [CMS (Cytoplasmic male sterile) 60/52 × R-43], namely Mehr were drilled in sub-plots at a row distance 60 cm apart and 15, 25 and 35 cm between plants in a row which corresponded to plant populations of 11.9, 6.66 and 4.7 plants m⁻², respectively. The seeds were planted on June 23 at Bajgah, and July 4, 1995 at Kushkak. Final plant population were achieved two wk after planting.

Irrigation was applied as necessary and the soil remained close to field capacity throughout the experiments. Weeds were controlled by hand 20 and 45 d after planting at both locations. The heads of the two central plant rows of each plot which were kept for final harvest were covered with newspaper completely right after pollination to prevent bird attacks.

Seeds were harvested on October 8 and 19 at Bajgah and Kushkak, respectively, excluding the extremes (50 cm on either side). Head size, seed number and weight per plant, percentage of unfilled seeds from five heads and seed yields (10% moisture) were determined. Seed oil and protein percentages were also determined according to AOAC (2) and modified Microkjeldahl procedures (2), respectively. The data were statistically analyzed by MSTAT C software program and the means were compared by Duncan's multiple range test.

RESULTS AND DISCUSSION

Increasing plant population significantly decreased head diameter due to competition for light and nutrients at both locations as also indicated by others (8, 9, 12). Maximum head diameter (19.8 cm) was obtained at Bajgah (Table 2) where there were favorable conditions for crop growth

(Table 1). Nitrogen fertilizer increased head diameter with no significant differences between 46, 69 and 92 kg N ha⁻¹ at both locations (Table 2). Unfilled seed percentages decreased by increasing plant populations and N applications at both locations (Table 2), confirming previous results (8, 11). This could be due to an increase in pollinated seed number, probable pollination by insect pollinators and the availability of more photosynthates to developing seeds. On the other hand, N deficiency can disturb the transfer of photosynthates to seeds and increase their unfillingness. Therefore, unfilled seeds strongly increased in the control treatment, and they were higher in Kushkak, probably due to higher temperatures (Table 1) and lower pollination by insects.

Higher plant population levels significantly decreased seed number and weight per plant at both locations (Table 2). This was due to decrease in head size which could have caused the abortion of the initiated florets. The larger the head, the higher the seed numbers. Nitrogen fertilizer also significantly increased seed number and weight per plant (Table 2) which was similar to the results of Sinswat and Steer (16). There were no significant interactions between plant population and N rates for seed number and weight per plant at both locations. However, seed number and weight were significantly higher at Bajgah than at Kushkak which could be due to fewer unfilled seeds and probably higher soil fertility (Tables 1 and 2). It seems that more photosynthates have moved to the filled seeds and increased their weight at Bajgah.

Seed yields significantly increased with increasing plant population, but there were no significant differences between 6.66 and 11.1 plants m⁻² (Table 2) as indicated by others (1, 8, 14, 15). The highest seed yield (3733.9 kg ha⁻¹) was obtained at Bajgah with 6.66 plants m⁻². Nitrogen fertilizer also significantly increased seed yields with no significant differences between 69 and 92 kg ha⁻¹ (Table 2). Interaction between plant population and N rates was not significant for seed yields at both locations which was similar to the Narwal and Malik (11) report. However, seed yields were significantly higher at Bajgah than at Kushkak (Table 2).

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Table 2. Effects of plant population and N rates on some agronomic features, seed and oil yields of sunflower at two locations.

	Population (plants m ⁻²)			Nitrogen rate (kg ha ⁻¹)						
	4.76	6.66	11.1	Mean	0	23	46	69	92	Mean
Head diameter (cm)	19.8a [†]	17.8b	14.5c	17.4A	16.1b	17.2a	17.2a	17.5a	17.8a	17.1A
Bajgah	18.2a	16.4b	15.1c	16.6B	14.8b	15.3b	16.7ab	16.8ab	18.1a	16.3B
Kuskak										
Unfilled seed (%)	9.2a	7.9a	7.8a	8.3B	11.3a	8.1b	7.6b	7.9b	6.8b	8.3B
Bajgah	19.7a	19.4a	18.5a	19.2A	22.5a	19.1b	18.8b	18.2b	17.5b	19.2A
Kuskak										
Seed number plant ⁻¹	1250a	1082b	700c	1010.7A	720b	1115a	1081a	1119a	1110a	1286.2A
Bajgah	845a	473b	468c	682.0B	440c	629.0b	753ab	748ab	768a	680.2B
Kuskak										
Seed weight plant ⁻¹ (g)	71.0a	56.1b	32.9c	53.3A	34.7c	52.8b	56.1ab	60.8a	62.3a	53.3A
Bajgah	60.8a	48.1b	28.6c	45.8B	26.6d	44.9c	48.8b	53.9a	54.8a	45.8B
Kuskak										
Seed yield (kg ha ⁻¹)	3380.6b	3733.9a	3658.1a	3588.9A	2346.5c	3547.6b	3799.9ab	4089.1a	4161.4a	3588.9A
Bajgah	2898.3b	3200.8b	3172.6a	3090.6B	1824.2d	3045.2c	3294.4b	3621.8a	3667.1a	3090.5B
Kuskak										
Oil yield (kg ha ⁻¹)	1598.0b	1804.8a	1801.0a	1734.6A	1163.1c	1719.1b	1856.5ab	1939.2a	1995.1a	1734.6A
Bajgah	1344.9b	1532.8a	1539.3a	1472.4B	918.0c	1474.8b	1555.8b	1707.4a	1705.8a	1472.4B
Kuskak										
Seed protein (%)	16.6a	14.8b	12.8c	14.7B	11.1c	14.0b	14.4b	15.5b	16.7a	14.3B
Bajgah	16.6a	16.4b	14.9b	16.0A	14.3c	15.0bc	16.0b	16.8ab	17.7a	16.0A
Kuskak										

[†] Means with the same small letters in each row and capital letters in each column (location) are not significantly different (Duncan 1%).

Increasing plant population increased oil yields mainly due to increase in seed yields with no significant differences between 6.66 and 11.1 plants m^{-2} at both locations (Table 2) which confirms the results of other investigators (6, 7, 11, 21). Nitrogen fertilizer increased the protein percentages of the seeds while decreasing oil percentages at both locations. Actually, there was an inverse relationship between the protein and oil percentages of sunflower seeds as also has been shown by others (3, 6, 10). However, oil yields significantly increased due to increase in seed yields with no significant difference between 69 and 92 kg N ha^{-1} (Table 2). The highest oil yield (1734.6 kg ha^{-1}) was obtained at Bajgah with 92 kg N ha^{-1} with no significant differences with 69 kg ha^{-1} , and it was in agreement with other reports (3, 8, 21). There was no significant interaction for plant population and N rates for oil yields at both locations.

There were a negative correlation between seed yield and unfilled seeds percentage at Kushkak ($R=-0.93$) and at Bajgah ($R=-0.56$). As the unfilled seed percentage increased, seed yield decreased. However, this correlation was highly significant only at Kushkak which can be attributed to the effects of higher temperatures and probably lower soil fertility as indicated earlier. There was also a positive correlation between seed yield and seed number per plant at Bajgah ($R=0.80$) and at Kushkak ($R=0.30$). These correlations were only significant at Bajgah with more favorable condition for seed set and filling as mentioned earlier and by others (10, 20).

Combined analysis over locations showed that Bajgah and Kushkak presented a significant differences in head diameter, seeds number and weight per plant, percentages of unfilled seeds, seed and oil yields. Therefore, head diameter, seeds number per plant and seed oil yield were higher at Bajgah due to lower temperatures for plant growth and its higher pollinators activity, and probably higher soil fertility level (Tables 1 and 2). Unfilled seed percentages were lower at Bajgah too. However, seed weight per plant and seed protein percentages were higher at Kushkak.

In summary, these investigations showed that increasing sunflower plant population increased seed and oil yields up to 6.66 plants m^{-2} , while decreased head diameter, seeds number and weight per plant, and seed

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protein percentages. Nitrogen fertilizer increased head diameter, seed number and weight per plant, seed and oil yields and protein percentages, while decreased the unfilled seeds.

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