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Safflower (*Carthamus tinctorius* L.) response to different nitrogen and phosphorus fertilizer rates in two planting seasons

Morvarid GOLZARFAR[1]*, Amir Hossein SHIRANI RAD[2], Babak DELKHOSH[1], Zahra BITARAFAN[1]

[1]Islamic Azad University, Science and Research Branch, Department of Agronomy
Tehran, Iran
*E-mail: Golzarfar_m@yahoo.com

[2]Seed and Plant Improvement Institute, Department of Oilseed Crops
Karaj, Iran

Abstract

Two field studies were conducted in Qazvin, Iran during the 2009–2010 autumn and winter planting seasons with the objective of determining the effect of nitrogen and phosphorus fertilizer rates on yield and yield components (number of heads per plant, number of heads on primary branch, number of heads on secondary branches, number of seeds per head, number of seeds per primary head, number of seeds per secondary head and 1000 seed weight) of safflower (*Carthamus tinctorius* L. cv. 'Goldasht'). The experiments were laid out in a three-replicated-randomized complete block design with three nitrogen (N) fertilizer rates ($N_1 = 0$, $N_2 = 75$, $N_3 = 150$ kg ha^{-1}) and three phosphorus (P) fertilizer rates ($P_1 = 0$, $P_2 = 50$, $P_3 = 100$ kg ha^{-1}) in two planting seasons (F) (F_1 = autumn, F_2 = winter). The study of simple effects of treatments indicated that increasing nitrogen and phosphorus rates increased all assessed traits in both seasons, while autumn planting had a significant preference in comparison to winter planting. The highest seed yield was obtained by application of 150 kg N ha^{-1}, 100 kg P_2O_5 ha^{-1} and autumn planting, on average 3227.50, 2641.83 and 2927.78 kg ha^{-1}, respectively. The study of interaction effects of treatments revealed that the highest seed yield was obtained in N_3P_3 and N_3F_1, on average 3474.86 and 4021.67 kg ha^{-1}, respectively.

Key words: safflower, *Carthamus tinctorius*, nitrogen rates, phosphorus rates, autumn and winter planting, yield and yield components.

Introduction

Safflower (*Carthamus tinctorius* L.) is a herbaceous annual broad-leaved plant and a member of the *Asteraceae* family. It is native to parts of Asia, the Middle East and Africa. It was grown mainly for its flowers, which were used in making dyes for clothing and food, but today, it is grown mainly for its oil. It grows well in both dry land and irrigated areas and is a drought-tolerant plant (Armah-Agyeman et al., 2002). The importance of safflower as oilseed crop has increased in recent years, especially with the increasing interest in the production of biofuels (Dordas, Sioulas, 2008).

The direct yield components of safflower are number of plants per plot, number of heads per plant, number of seeds per head and weight of seeds (Gilbert, Tucker, 1967). The relative importance of each yield component is affected by many factors, including genotype, environmental conditions and cultural practices. Sowing time and nutrient management are important parameters affecting yield and yield components in safflower.

Nutrient management is one of the critical inputs in achieving high productivity of safflower (Mündel et al., 2004). One of the most important methods for increasing agricultural production in crop management practices is to increase the efficiency of fertilizer dose. With this aim in view, optimum fertilizer application ratios, fertilizer content, nutritional requirements of the plant during the growth season, and the amounts of nutrients present in the soil should be ascertained (Alivelu et al., 2006; Dong et al., 2005). Nitrogen and phosphorus are the two essential nutrients for safflower growth and development, therefore optimization of their rates can strongly increase the seed yield and oil content in safflower. Suggestions for fertilizers with nitrogen should be made to ensure a high-quality product, optimum yield, high profit and lesser environmental pollution risks (Belanger et al., 2000; Antoniadou, Wallach, 2002; Henke et al., 2007).

The other key point for optimizing safflower productivity in a given location is the choice of the appropriate sowing date (Esendal, 1997). Several studies conducted in different parts of the world have shown that safflower could be grown as a winter crop in areas with mild temperatures or as a spring crop in cooler areas, although autumn sowing produces a significant increase in seed yield over that sown in spring (Koutroubas et al., 2004; Yau, 2007). In warmer Mediterranean areas, like California, safflower is usually planted in the spring to prevent excessive vegetative growth leading to poor seed yield (Kaffka, Kearney, 1998). In cooler Mediterranean areas, like central Italy, it was reported that fall sowing of safflower frequently resulted in crop failure as safflower has little resistance to low temperature even during the rosette stage (Salera, 1997). However, in southern Italy, where the weather is milder, fall-sown safflower yielded more than spring-sown (Cazzato et al., 1997; Corleto et al., 2001).

Currently, sufficient data on safflower production management is lacking. Therefore, the key objectives of the present study were to determine the effect of different nitrogen and phosphorus fertilizer rates as well as planting time on safflower in order to optimize cultivation criteria for the production of the safflower.

Materials and methods

Experimental site and design. The experiment was carried out at the experimental farm in Qazvin, Iran (49°57′ E, 36°18′ N; 1314 m above sea level) in the autumn and winter of the 2009–2010 growing seasons. Annual rainfall in Qazvin is 312 mm with the maximum and minimum temperatures of 8.2 and 38.7°C, respectively in a 30-year period. The soil of the experimental site was a clay loam soil. The soil characteristics-were determined before the experiment (Table 1).

Table 1. Soil characteristics of the experimental site in Qazvin, Iran

Characteristic	Depth cm	
	0–30	30–60
Clay %	29	27
Silt %	45	46
Sand %	26	27
Available K mg kg^{-1}	165	148
Available P mg kg^{-1}	14.2	15.3
Total N %	0.08	0.06
Organic carbon %	0.83	0.96
TNV %	8.25	8.46
Sp %	35	37
pH 1:1 H_2O	7.8	7.4
EC dS m^{-1}	1.33	1.15
Soil texture	CL	CL

The experimental design was a factorial arrangement in the form of randomized complete block design with three replications. Treatments included three nitrogen (N) fertilizer rates (N_1 = 0, N_2 = 75, N_3 = 150 kg ha^{-1}) in the form of urea, three phosphorus (P) fertilizer rates (P_2O_5) (P_1 = 0, P_2 = 50, P_3 = 100 kg ha^{-1}) in the form of triple superphosphate and two planting seasons (F) (F_1 = autumn, F_2 = winter).

Each experimental plot consisted of 6 rows, 4 m long with 30 cm spaces between rows and 6 cm distance between plants in the rows. The safflower (*Carthamus tinctorius* L.) cultivar 'Goldasht' was used in the experiment. Plant density was 55.6 plants m^{-2}. Each N treatment was used in three stages: one-third pre-plant, one-third at stem elongation stage and one-third at flowering stage. Each P treatment was used pre-plant with K at a rate of 150 kg ha^{-1} K_2O in the form of K_2SO_4. Seeds in autumn and winter planting were planted on 7 October 2009 and 6 March 2010, respectively. The final harvesting was performed in autumn and winter planting on 24–28 July 2010 and 6–11 August 2010, respectively at physiological maturity stage. Four middle rows were used for sampling and measurement of parameters such as seed yield, number of heads per plant, number of heads on primary branch, number of heads on secondary branches, number of seeds per head, number of seeds per primary head, number of seeds per secondary head and 1000 seed weight. Ten plants from the middle of each plot were harvested as samples. Also, the crop was kept free from weeds by applying 2.5 l ha^{-1} Trifluralin pre-plant and 2–3 l ha^{-1} Bentazon for the control of broadleaf weeds at four-leaf stage.

Measurements of traits. The following parameters were determined: seed yield, number of heads per plant, number of heads on primary branch, number of heads on secondary branches, number of seeds per head, number of seeds per primary head, number of seeds per secondary head and 1000 seed weight. Seed yield and number of heads were determined by harvesting 10 plants at random from the four central rows at physiological maturity stage. Seed yield in each plot was adjusted to 14% moisture. Number of seeds per head was determined by measuring 30 heads at random from 10 randomized harvested plants. 1000 seed weight was determined by measuring the weight of 8 random samples, each consisting of 100 seeds, from each plot and multiplying it by 10 in order to express it in 1000 seeds.

Statistics. The experiments were conducted in 2009–2010 during the autumn and winter planting seasons with three replications in each treatment. Analyses were performed using the *SAS* software. A factorial analysis of variance (*ANOVA*) was performed for all parameters. In addition, the Duncan's multiple range test (DMRT) (P = 0.05) was used to conduct mean comparison of treatments and find significant differences among means.

Results and discussion

Variance components and mean comparisons for seed yield, number of heads per plant, number of heads on primary branch, number of heads on secondary branches, number of seeds per head, number of seeds per primary head, number of seeds per secondary head and 1000 seed weight are presented in Tables 2 and 3, respectively. The results of factorial analysis of variance (*ANOVA*) revealed that the simple effects of variance components (N, P and F) were significant at P = 0.01 for all assessed traits (Table 2). The interaction effect of nitrogen × phosphorus was significant at P = 0.01 for all assessed traits except for number of seeds per head and number of seeds per primary head. The interaction effect of nitrogen × planting season was significant at P = 0.01 for all assessed traits except for number of seeds per primary head which was significant at P = 0.05. The interaction effects of phosphorus × planting season and nitrogen × phosphorus × planting season were significant just for the number of seeds per secondary head at P = 0.05 (Table 2).

Nitrogen fertilization affected seed yield and the yield components. Seed yield increased with increasing N rates from 0 to 150 kg ha^{-1} as the highest seed yield, on average 3227.50 kg ha^{-1} was obtained by application of 150 kg ha^{-1} (Table 3). Generally, in most previous studies seed yield was increased by N fertilization at different rates depending on the experiment. Mündel et al. (2004) reported that safflower requires 5 kg ha^{-1} of N to produce 100 kg ha^{-1} of seed. Dordas and Sioulas (2008) reported that nitrogen fertilization increased seed yield on average 19%. Also, yield components were increased by N fertilization. Number of heads per plant, number of heads on primary branch and number of heads in secondary branches increased by increasing N rates from 0 to 150 kg N ha^{-1} and ranged from 16.35 to 23.88, 5.31 to 9.11 and 11.03 to 14.76, respectively, as affected by N supply (Table 3). Dordas and Sioulas (2008) reported that nitrogen fertilization increased number of heads per plant on average 32%. Strasil and Vorlicek (2002) reported that N fertilization did not affect the number of heads per plant, which disagrees with our study. The number of seeds per head, number of seeds per primary head and number of seeds per secondary head all increased by increasing N rates from 0 to 150 kg ha^{-1}. Generally, the seed number per head in safflower ranged from 17 to 39 (Sergek, 2001). The number of seeds per head, number of seeds per primary head and number of seeds per secondary head ranged from 13.50 to 28.68, 14.43 to 32.50, 12.51 to 24.81, respectively, as affected by N supply in our study (Table 3). 1000 seed weight increased with N fertilization from 0 kg ha^{-1} to 150 kg ha^{-1} and ranged between 20.01 to 34.71 g (Table 3). Strasil and Vorlicek (2002) reported that N fertilization did not affect 1000 seed weight, which disagrees with our study.

Table 2. Factorial analysis of variance components (nitrogen (N) rate, phosphorus (P) rate, planting season (F) and their interactions) for assessed traits

VC	DF	NH/P	NH/PB	NH/SB	NS/H	NS/PH	NS/SH	TSW	SY
Replication	2								
Nitrogen rate	2	**	**	**	**	**	**	**	**
Phosphorus rate	2	**	**	**	**	**	**	**	**
Planting season	1	**	**	**	**	**	**	**	**
Nitrogen × phosphorus	4	**	**	**	ns	ns	**	**	**
Nitrogen × planting season	2	**	**	**	**	*	**	**	**
Phosphorus × planting season	2	ns	ns	ns	ns	ns	*	ns	ns
Nitrogen × phosphorus × planting season	4	ns	ns	ns	ns	ns	*	ns	ns
Error	34								
Total	53	–	–	–	–	–	–	–	–
CV %	–	1.575	2.717	1.486	6.925	10.951	3.286	1.640	2.560

Notes. *, ** – significant at 5% and 1% respectively, ns – not significant. Traits NH/P, NH/PB, NH/SB, NS/H, NS/PH, NS/SH, TSW and SY are assigned for number of heads per plant, number of heads on primary branch, number of heads on secondary branches, number of seeds per head, number of seeds per primary head, number of seeds per secondary head, 1000 seed weight in g and seed yield in kg ha^{-1}, respectively.

Table 3. Simple effects of nitrogen rate, phosphorus rate and planting season on assessed traits

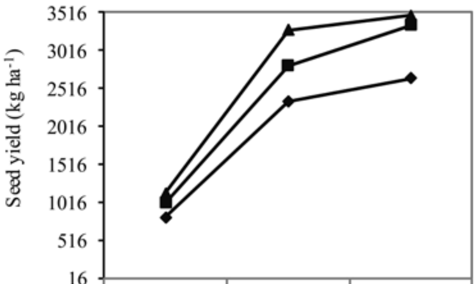
Treatments	Mean							
	NH/P	NH/PB	NH/SB	NS/H	NS/PH	NS/SH	TSW g	SY kg ha^{-1}
Nitrogen rate kg ha^{-1}								
0	16.35^{c}	5.31^{c}	11.03^{c}	13.50^{c}	14.43^{c}	12.51^{c}	20.01^{c}	983.83^{c}
75	22.60^{b}	8.48^{b}	14.11^{b}	25.85^{b}	29.15^{b}	22.48^{b}	32.16^{b}	2757.83^{b}
150	23.88^{a}	9.11^{a}	14.76^{a}	28.68^{a}	32.50^{a}	24.81^{a}	34.71^{a}	3227.50^{a}
Phosphorus rate kg ha^{-1}								
0	19.65^{c}	7.03^{c}	12.61^{c}	20.05^{c}	22.55^{b}	17.50^{c}	26.28^{c}	1935.83^{c}
50	21.21^{b}	7.78^{b}	13.43^{b}	23.17^{b}	25.91^{a}	20.36^{b}	29.38^{b}	2391.50^{b}
100	21.96^{a}	8.10^{a}	13.86^{a}	24.81^{a}	27.61^{a}	21.95^{a}	31.23^{a}	2641.83^{a}
Planting season								
Autumn	22.98^{a}	8.67^{a}	14.31^{a}	26.52^{a}	29.86^{a}	23.12^{a}	32.58^{a}	2927.78^{a}
Winter	18.90^{b}	6.60^{b}	12.30^{b}	18.83^{b}	20.85^{b}	16.75^{b}	25.34^{b}	1718.33^{b}

Note. Any two means sharing a common letter do not differ significantly from each other at 5% probability. Explanations of the abbreviations are presented under Table 2.

Phosphorus fertilization affected seed yield and the yield components. Seed yield increased with increasing P rates from 0 to 100 kg ha^{-1} as the highest rate of seed yield, on average 2641.83 kg ha^{-1} was obtained by application of 100 kg ha^{-1} P (Table 3). Singh et al. (1995) reported that application of 26.4 kg ha^{-1} P gave significantly higher seed yield (1.43 t ha^{-1}) and oil yield (439 kg ha^{-1}) than the control and 13.2 kg ha^{-1} P. Abbadi and Gerendas (2011) reported that safflower responded strongly to increasing P supply with respect to plant growth and yield. Also, yield components were increased by P fertilization. Number of heads per plant, number of heads on primary branch and number of heads in secondary branches increased by increasing P rates from 0 to 100 kg ha^{-1} and ranged from 19.65 to 21.96, 7.03 to 8.10 and 12.61 to 13.86, respectively, as affected by P supply (Table 3). The number of seeds per head, number of seeds per primary head and number of seeds per secondary head all increased by increasing P rates from 0 to 100 kg ha^{-1}, although the difference among number of seeds per primary head in 50 and 100 kg ha^{-1} P_2O_5 was not prominent. Number of seeds per head, number of seeds per primary head and number of seeds per secondary head ranged from 20.05 to 24.81, 22.55 to 27.61, 17.50 to 21.95, respectively, as affected by P supply (Table 3). 1000 seed weight increased with P fertilization from 0 to 100 kg ha^{-1} N and ranged between 26.28 to 31.23 g (Table 3). According to the results of previous researches, 1000 seed weight of safflower cultivars varied between 33.47 and 42.66 g (Sergek, 2001). Phosphorus participates in creating plants genetic constructions and its deficiency decreases growth rate and grain yield production (Herdrich, 2001). Sary et al. (1988) reported that application of nitrogen and phosphorus significantly increased yield and yield component characteristics of safflower.

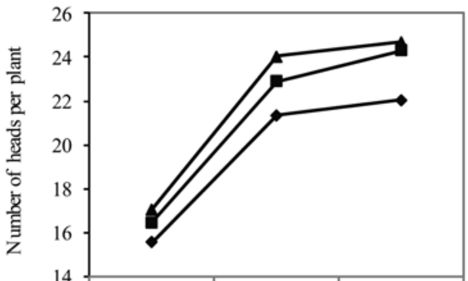
Planting season affected seed yield and the yield components, and autumn planting showed a significant preference in comparison to winter planting. The highest seed yield, number of heads per plant, number of heads on primary branch, number of heads on secondary branches, number of seeds per head, number of seeds per primary head, number of seeds per secondary head and 1000 seed weight, on average 2927.78 kg ha^{-1}, 22.98, 8.67, 14.31, 26.52, 29.86, 23.12 and 32.58 g were obtained in autumn planting (Table 3). This can be because the flowering period in winter planting falls in June, when evapotranspiration reaches high values and a long water stress period starts (Koutroubas et al., 2004; 2009; Yau, 2007). Flowering is the most sensitive plant stage to water deficit (Movahhedy-Dehnavy et al., 2009). Moreover, various safflower diseases tend to spread and intensify towards and after flowering. Therefore, plants are subjected to several biotic and abiotic stresses during the seed filling period that diminish photosynthesis and crop nitrogen uptake limiting their production.

The study of the interaction effect of N and P revealed that the highest seed yield, number of heads per plant, number of heads on primary branch, number of heads on secondary branches, number of seeds per secondary head and 1000 seed weight were obtained in N_3P_3 (application of 150 kg ha^{-1} N and 100 kg ha^{-1} P_2O_5), on average 3474.86 kg ha^{-1}, 24.7, 9.442, 15.256, 26.571 and 36.514 g, respectively, although the difference among N_2P_3, N_3P_2 and N_3P_3 in production of the highest rate of number of heads on primary branch was negligible. The lowest seed yield, number of heads per plant, number of heads on primary branch, number of heads on secondary branches, number of seeds per secondary head and 1000 seed weight obtained in N_1P_1 (application of 0 kg ha^{-1} N and 0 kg ha^{-1} P_2O_5) were on average 817 kg ha^{-1}, 15.55, 5, 10.55, 11.4 and 18.55 g, respectively (Figs 1–6). In all rates of one fertilizer, the highest rate of the other one is preferable.



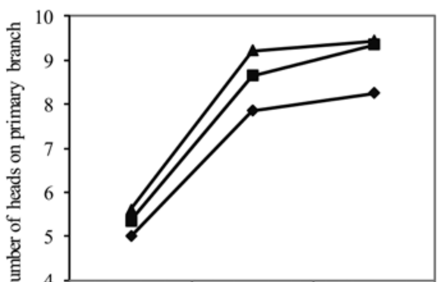
	N_0	N_{75}	N_{150}
P_0	817	2341,5	2649
P_{50}	1004.5	2818	3352
P_{100}	1130	3289.8	3474.86

Figure 1. Interaction effect of N rate and P rate on seed yield



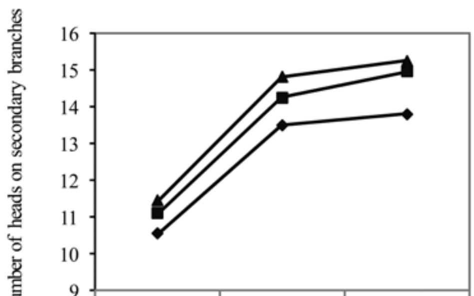
	N_0	N_{75}	N_{150}
P_0	15.55	21.35	22.05
P_{50}	16.45	22.9	24.3
P_{100}	17.05	24.04	24.7

Figure 2. Interaction effect of N rate and P rate on the number of heads per plant



	N_0	N_{75}	N_{150}
P_0	5	7.85	8.25
P_{50}	5.35	8.65	9.35
P_{100}	5.6	9.22	9.44

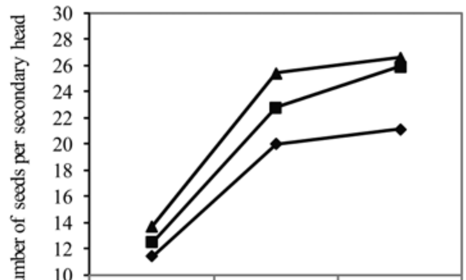
Figure 3. Interaction effect of N rate and P rate on the number of heads on primary branch



	N_0	N_{75}	N_{150}
P_0	10.55	13.5	13.8
P_{50}	11.1	14.25	14.95
P_{100}	11.45	14.82	15.25

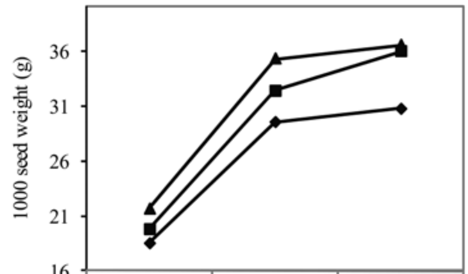
Figure 4. Interaction effect of N rate and P rate on the number of heads on secondary branches

The study of the interaction effect of N and F revealed that the highest seed yield, number of heads per plant, number of heads on primary branch, number of heads on secondary branches, number of seeds per head, number of seeds per primary head, number of seeds per secondary head and 1000 seed weight were obtained in N_3F_1 (application of 150 kg ha^{-1} N in autumn planting, on average 4021.67 kg ha^{-1}, 26.3, 10.333, 15.966, 33.622, 38.067, 29.133 and 39.333 g, respectively and the lowest seed yield, number of heads per plant, number of heads on primary branch, number of heads on secondary branches, number of seeds per head, number of seeds per primary



	N_0	N_{75}	N_{150}
P_0	11.4	20	21.1
P_{50}	12.45	22.75	25.9
P_{100}	13.7	25.38	26.57

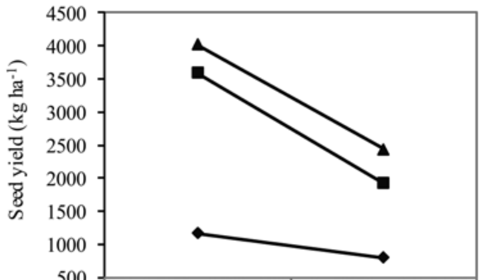
Figure 5. Interaction effect of N rate and P rate on the number of seeds per secondary head



	N_0	N_{75}	N_{150}
P_0	18.55	29.55	30.75
P_{50}	19.8	32.4	35.95
P_{100}	21.7	35.28	36.51

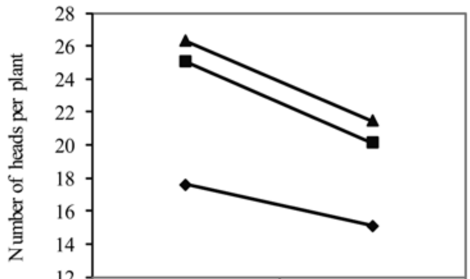
Figure 6. Interaction effect of N rate and P rate on 1000 seed weight

head, number of seeds per secondary head and 1000 seed weight were obtained in N_1F_2 (application of 0 kg ha^{-1} N in winter planting), on average 799.33 kg ha^{-1}, 15.1, 4.8, 10.3, 11.622, 12.333, 10.866 and 17.833 g, respectively (Figs 7–14). Although autumn planting is more preferable than winter planting, the application of 150 kg ha^{-1} N and then 75 kg ha^{-1} N in winter planting had a significant preference in comparison to non-application of N in autumn planting.



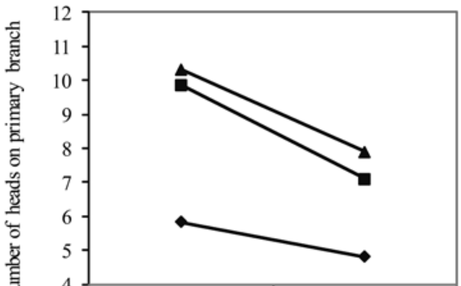
	Autumn	Winter
N_0	1168.33	799.33
N_{75}	3593.33	1922.33
N_{150}	4021.67	2433.33

Figure 7. Interaction effect of N rate and planting season on seed yield



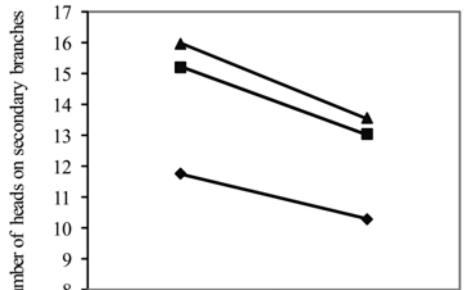
	Autumn	Winter
N_0	17.6	15.1
N_{75}	25.06	20.13
N_{150}	26.3	21.46

Figure 8. Interaction effect of N rate and planting season on the number of heads per plant



	Autumn	Winter
N_0	5.83	4.8
N_{75}	9.86	7.1
N_{150}	10.33	7.9

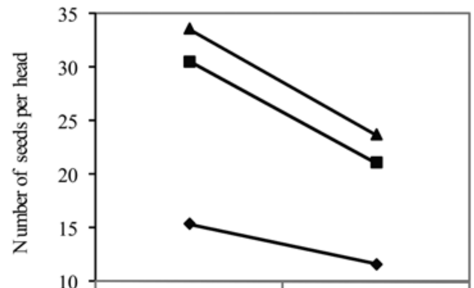
Figure 9. Interaction effect of N rate and planting season on the number of heads on primary branch



	Autumn	Winter
N_0	11.76	10.3
N_{75}	15.2	13.03
N_{150}	15.96	13.56

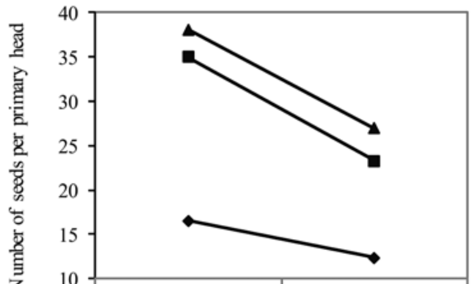
Figure 10. Interaction effect of N rate and planting season on the number of heads on secondary branches

The study of the interaction effect of P and F revealed that the highest and lowest number of seeds per secondary head was obtained in P_3F_1 (application of 100 kg ha^{-1} P_2O_5 in autumn planting) and P_1F_2 (application of 0 kg ha^{-1} P_2O_5 in winter planting), on average 25.566 and 14.833, respectively (Fig. 15). In winter planting, the highest number of seeds per secondary head was obtained by application of 100 kg ha^{-1} P_2O_5.



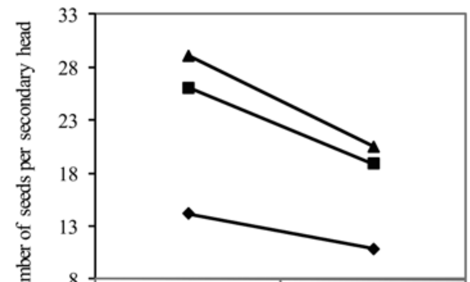
	Autumn	Winter
N_0	15.37	11.62
N_{75}	30.56	21.13
N_{150}	33.62	23.74

Figure 11. Interaction effect of N rate and planting season on the number of seeds per head



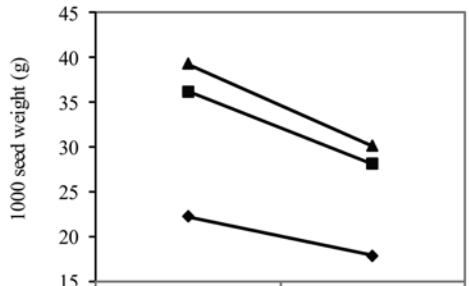
	Autumn	Winter
N_0	16.53	12.33
N_{75}	35	23.3
N_{150}	38.06	26.93

Figure 12. Interaction effect of N rate and planting season on the number of seeds per primary head



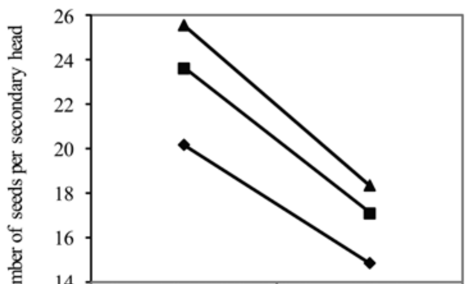
	Autumn	Winter
N_0	14.16	10.86
N_{75}	26.06	18.9
N_{150}	29.13	20.5

Figure 13. Interaction effect of N rate and planting season on the number of seeds per secondary head



	Autumn	Winter
N_0	22.2	17.83
N_{75}	36.23	28.1
N_{150}	39.33	30.1

Figure 14. Interaction effect of N rate and planting season on 1000 seed weight



	Autumn	Winter
P_0	20.16	14.83
P_{50}	23.63	17.1
P_{100}	25.56	18.33

Figure 15. Interaction effect of P rate and planting season on the number of seeds per secondary head

The study of the interaction effect of N, P and F revealed that the highest and lowest number of seeds per secondary head was obtained in $N_3P_3F_1$ (application of 150 kg ha^{-1} N and 100 kg ha^{-1} P_2O_5 in autumn planting) and $N_1P_1F_2$ (application of 0 kg ha^{-1} N and 0 kg ha^{-1} P_2O_5 in winter planting), on average 32.8 and 9.6, respectively (data not shown). In winter planting, the highest number of seeds per secondary head was obtained by application of 150 kg ha^{-1} N and 100 kg ha^{-1} P_2O_5.

Conclusions

Fertilizer management and choice of the optimal planting time are the two major agronomic practices affecting productivity. The present study provides new findings about the effects of N and P rates and planting season on the yield and yield components of safflower (*Carthamus tinctorius* L.) cv. 'Goldasht'. In our study 1) by increasing the rate of N and P, the seed yield and yield components increased in both autumn and winter planting, although autumn planting showed a significant preference in comparison to winter planting; 2) in all rates of one fertilizer, the highest rate of other one was preferable while both fertilizers were used; 3) application of 150 kg ha^{-1} N in autumn planting had a significant preference in comparison to other treatments, but also in the case of winter planting, application of 150 kg ha^{-1} N was more preferable than the other rates of N; 4) application of 100 kg ha^{-1} P_2O_5 in both season was preferable too. The response of the assessed traits to N and P rates and planting season can be used to suggest management strategies for safflower cultivation.

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Įvairių normų azoto ir fosforo trąšų įtaka dažinio dygmino (*Carthamus tinctorius* L.) augimui, sodinant rudenį ir žiemą

M. Golzarfar[1], A. H. Shirani Rad[2], B. Delkhosh[1], Z. Bitarafan[1]

[1]Teherano islamiškasis Azad universitetas, Iranas
[2]Karaj sėklų ir augalų tyrimo institutas, Iranas

Santrauka

Du lauko bandymai buvo vykdyti Qazvin vietovėje, Irane, 2009–2010 m. rudens ir žiemos sodinimo sezonais, siekiant nustatyti azoto bei fosforo trąšų normų įtaką dažinio dygmino (*Carthamus tinctorius* L., veislė 'Goldasht') derliui ir jo komponentams: galvučių skaičiui augale, galvučių skaičiui ant pagrindinės ir šalutinių šakų, sėklų skaičiui galvutėje, sėklų skaičiui pagrindinėje ir šalutinėje galvutėse ir 1000 sėklų masei. Kelių veiksnių bandymas buvo įrengtas pagal trijų atsitiktine tvarka išdėstytų pakartojimų blokų schemą su trimis azoto (N) (N_1 = 0, N_2 = 75, N_3 = 150 kg ha^{-1}) bei trimis fosforo (P) (P_1 = 0, P_2 = 50, P_3 = 100 kg ha^{-1}) trąšų lygiais ir vykdytas du sodinimo sezonus (F) (F_1 = ruduo, F_2 = žiema). Tyrimas parodė, kad didinant azoto ir fosforo trąšų normas, visų tirtų požymių vertės didėjo abiem sezonais, tačiau rudeninis sodinimas buvo pranašesnis už žieminį. Didžiausias sėklų derlius gautas patręšus 150 kg ha^{-1} N, 100 kg ha^{-1} P_2O_5 ir sodinant rudenį, vidutiniškai 3227,50, 2641,83 ir 2927,78 kg ha^{-1}. Variantų sąveikos poveikio tyrimas parodė, kad didžiausias sėklų derlius gautas patręšus N_3P_3 ir N_3F_1 – vidutiniškai 3474,86 ir 4021,67 kg ha^{-1}.

Reikšminiai žodžiai: dažinis dygminas, *Carthamus tinctorius*, azoto normos, fosforo normos, sodinimas rudenį ir žiemą, derlius ir derliaus komponentai.