UDK 630.861(55)

Mohtasham MOHAMMADI and Rahmatollah KARIMIZADEH [1]

RESPONSE OF SAFFLOWER TO ROW SPACING AND INTRA-ROW PLANT DISTANCE IN SEMI-WARM DRYLAND CONDITION

ABSTRACT

To achieve the highest safflower yield, in addition to optimum row spacing, suitable distribution of plants on the row has great importance. This research was conducted in strip plot arrangement with base of complete block design in three replications. Row spacing (15, 30, 45 and 60 cm) and intra-row plant density were located in vertical and horizontal plots respectively. It was done at Gachsaran Dryland Agricultural Research Station using PI537598 (Sina Cultivar). The highest yield (812 kg/ha) were obtained at 15cm row spacing, but the maximum number of capitula per plant (12.1 capitula) and number of grain per capitula (12.6 grain) that were significant specified to 60cm row spacing. Intra-row plant distance was significant on grain yield and most of its yield components. Plant distance of 10 cm had the highest grain yield (830 kg/ha), but, the maximum number of capitula per plant (11.7 capitula) and number of grain per capitula (12.9 grain) belonged to 40cm plant distance on the row. Thousand kernel weight were not affected under different treatments. Therefore, 10×15cm treatment showed the highest grain yield and there was no interaction effect between row spacing and plant distance on the row. It seems that high plant population can compensate reduction in yield components and finally produce more grain/oil yield.

Keywords: Drought, Plant arrangement, Yield components, Environment potential

INTRODUCTION

For the last fifty years, safflower was primarily cultivated for production of high-quality vegetable oil in semiarid regions of Asia, Australia, Americas and Europe. The importance of vegetable oil crops has increased over the years following a higher consumer demand for healthier edible oils (Yau, 2009). Further potential benefits of incorporating safflower into rotations include; production on sodic or saline soils (Van-Hoorn, 1991), improvements to soil structure (Materechera et al., 1993), a break crop for cereal diseases (Colton, 1988), increased biodiversity, management flexibility, spread of economic risk, slow the evolution of herbicide resistant weeds and economic vulnerability. Safflower's deep tap root and high water use may be beneficial in drying soil profiles (Beach and Leach, 1989).

[1] Mohtasham Mohammadi (corresponding author: mohtashammohammadi@yahoo.com), Rahmatollah Karimizadeh, Dryland Agricultural Research Institute. Gachsaran station. P.O.Box 178. Iran.

To optimize the use of genetic values and environmental qualities and succeeded in developing a farm system, the knowledge of plant genotype × environmental conditions interaction is essential. With knowledge of mutual relationships between climate and development of yield components, the effects of adverse weather also reduced.

Since plant density and its arrangement depend on the conditions of the environments, such as moisture availability and temperature the crop during the growing season, properties of cultivars, level of mechanization used in preparing the land, skills of farmers, competing weeds, the time of seeding, row spacing and method of seeding, it is not surprising that different row spacing and plant arrangements are being used for commercial production of safflower in different areas of the world.

In safflower production row spacing is important because it determines the yields. Seed yields increase with narrow row spacing. Hoag et al. (1968) concluded that yields from 15 or 53 cm spaced rows were greater than the yields from 91 cm rows. The results of Qayyum et al., (1986) showed that all the growth and yield properties increased with 20 cm row spacing. Esendal (1986) found that seed yield of safflower decreased significantly ($P<0.05$), as the row distance was increased from 18 to 90 cm. The seed yields obtained from 18, 54 and 90 cm rows were 235.6, 199.8 and 184.1 kg ha-1, respectively in Erzurum Valley. Gencer et al. (1987) reported that the suitable plant spacing was 34 cm at the unirrigated area of Cukurova region in Turkey. Knowles and Miller (1965) recommended 45-60 cm row spacing when the safflower is grown on dry land. Salera (1996) reported that safflower planting in rows with a distance of 25 cm, has been a drastic reduction in the level of weed infestation in compare to rows 50 cm. Weiss (2000) summarized that seed rates of 30- 60 kg ha-1, dependent on the variety and environment (rainfed or irrigated), are commonly used for large commercial crops (Weiss, 2000).

Grain yield is increased by reducing row spacing(Morrison, et al., 1990; Azari, 2001; Board., 2004.; Mundel et al., 2004), because better distribution of plants in the narrow row spacing and less competition increase yield components (Morrison et al., 1990).

High density of vegetation cause early competition. This issue results in faster reduction of relative growth rate, but plants grow more in low densities. Because the less number of plants per unit area before competition reduces their growth rate, they will have greater opportunities for growth (Mohammadi, 1999).

In most crops, including safflower in very low densities, it may not occur competitive at all and nutrition sources do not used with optimum efficiency. In the other hands, different row spacing and less or more intra row are effective in efficient usage of existing sources and precedence or lateness in beginning time of competition inside and outside of plants.

The main objectives of this study were to determine the best spacing between rows and seeds intra-rows of to obtain the best arrangement pattern of safflower in semi warm dryland conditions that way can optimize the use of environmental features, to the extent possible the intended use of the capabilities inherited genotype.

MATERIAL AND METHODS

Field experiment was conducted at the Gachsaran Dryland Agricultural Research Station (30°20'N, 50°50'E, 710 m above sea level) of Dryland Agricultural Research Institute (DARI) which cover the semi-warm dryland regions of Iran. The long-term annual precipitation of the site is 430 mm, most of which falls in December, January and February. Terminal heat and drought stresses were occurred as usual. The soil type was a silty clay loam with a pH of 7.0 and 1 % organic matter.

To prepare the sowing bed, plow operation was carried out using plough and disk. Based on soil test the required fertilizer was applied. Nitrogen and phosphorous fertilizers were applied in rates of 60 and 60 kg/ha simultaneously with planting. Plot sizes were 7 m long. All culture practice operations were performed manually. Controlling the weeds was done using manual hand weeding during two stages. After removal of 50 cm from the beginning and the end of each split plot, 10 random plants were selected from medial rows to determine considered traits.

Experiment design was strip plot arrangement as complete block base with 3 replications. Vertical plots were row spacing (15, 30, 45 and 60 cm), horizontal plots were plant distance on rows (10, 20, 30 and 40 cm). The selected safflower cultivar was PI537598 (Sina) as adaptive cultivar.

The fallowing parameters were investigated: Plant height, Times of flowering and maturity, number of capitula per plant, number of grain per capitula. To measure and determine the 1000-grain weight, 1000 grains from each experiment plot were randomly selected and calculated using a digital scale. Final harvesting was performed by Steiger machine in order to estimate grain yield.

Data were statistically analyzed using SAS software and to compare treatments means Duncan method were used.

RESULTS AND DISCUSSION

Weather

Precipitation was below the long-term average in 2000-01 (280 mm). The season started normally around mid-November and received 234 mm precipitation but, little rainfalls fell after January. There was no any rainfall after flowering. Monthly average temperatures were close to the long-term means in December, January and February, but for March, April and May, it were 3, 4.2 and 2°C warmer than the usual.

Row Spacing Effects

The wide row spacing (45 and 60 cm) increased the number of capitula, number of grain per capitula and seed weight. These differences were statistically significant ($P<0.01$), except the seed weight. The narrowest row spacing (15 cm) gave the maximum seed yield (812 kg ha^{-1}) which was not significantly ($P<0.05$) different than the other spacing. The decreases in the seed yields were 14.5, 4.9, and 10.1% for 40 and 60 cm row spacing, respectively, in comparison to 30, 45 and 60 cm spacing (Table 1).

Patel et al. (1994) stated that the highest grain yield for 30, 45 and 60 cm rows were obtained for narrow row of 30cm. Cobley, et al. (1997) was found the most yield as: 2.4 t/ha from 25 cm row spacing in Italy. Other report also showed that grain yield increases with decrease in row spacing (Mundel et al., 2004).

In some studies, with increasing in row spacing (Esmi, 1997; Azari, 2001) due to more light penetration, minor branches which terminate to capitula were increased. The results of different experiments indicating less minor branches after increasing the plant density (Gonzalez, et al., 1994; Esmi, 1997; Zareian, 2001; Azari, 2001).

Plant distance intra-row

The seed yield affected significantly by treatments. The highest seed yield (83 kg ha^{-1}0) was obtained in 10 cm distance followed by 40, 30 and 20cm plant distance. The highest number of capitula per plant, number of grain per capitula and seed weight belong to 40 cm distance intra-row, which were significant in compare to 10cm (Table 2).

A significant interaction was not found between Row Spacing Interactions x Intra-row plant distance. In the other hand, the trend of seed yield for different plant distances in one row was similar.

Obtained results of experiments show increasing the number of capitula per plant, number of grains per capiluta in safflower (Nasr, et al., 1978; Azari, 2001) and soybean (Uslu, et al., 1998) due to narrow spacing. Ozel, et al. (2004) in two year study were observed that the highest seed yield was obtained in the 5 cm plant distance in turkey. Many experiments (Gonzalez et al., 1994; Naser et al., 1997; Azari, 2001; Zareaian, 2001) showed that high seed density reduce the capitula per plant, seed per capitula, and seed weight (Esmi, 1997; Zareian, 2001). Some experiments showed seed density have not effect on thousand kernel weight (Gonzalez et al., 1994; Naser et al., 1978; Blachshaw, 1993).

Oil Percent

According to variance analysis, oil percent was not significant under none of experimental factors (Tables 1&2). Robertson et al., (2004) believed that oil percent depends on the type of cultivar and it is not influenced by environmental factors. Reports showed that row spacing does not affect the amount of grain oil (Mundel et al., 2004; Morrison et al., 1997; Johonson and hanson 2003). Naseri et al. (2010) showed in an experiment on safflower in rainfed condition that oil percent was not significant under the influence of row and plant spacing. However, it is clear that oil yield increase in application of narrow row spacing, due to higher seed yield which has agreement with Ozel, et al. (2004).

Table 1- The effects of row spacing on grain yield, its components and oil percent based on DMRT in 5 and 1% probability level

Row spacing	Grain yield			Capitula per plant			Grain per capitula			Thousand kernel weight			Oil percent		
	Kg/ha	5%	1%	No.	5%	1%	No.	5%	1%		5%	1%	percent	5%	1%
15	812.0	A	A	6.5	B	C	8.6	C	B	46.7	A	A	23.7	A	A
30	709.2	A	A	8.1	B	BC	11.3	AB	AB	46.6	A	A	23.5	A	A
45	773.5	A	A	10.5	A	AB	10.6	B	AB	47.2	A	A	23.5	A	A
60	737.2	A	A	12.1	A	A	12.6	A	A	47.6	A	A	23.4	A	A

DMRT: Dunkan;s multiple range test
Mean which have at least once common letter are not significant

Table 2- The effects of intra-row plant density on grain yield, its components and oil percent based on DMRT in 5 and 1% probability level

Plant distance	Grain yield			Capitula per plant			Grain per capitula			Thousand kernel weight			Oil percent		
	Kg/ha	5%	1%	No.	5%	1%	No.	5%	1%		5%	1%	percent	5%	1%
10	830.2	A	A	6.0	C	B	9.4	B	B	44.3	B	A	23.4	A	A
20	712.7	B	A	9.3	B	A	9.2	B	B	47.0	AB	A	23.7	A	A
30	736.4	A	A	10.3	AB	A	11.6	A	AB	47.6	AB	A	23.5	A	A
40	752.2	A	A	11.7	A	A	12.9	A	A	49.1	A	A	23.6	A	A

DMRT: Dunkan;s multiple range test
Mean which have at least once common letter are not significant

CONCLUSIONS

It was concluded that row spacing and intra- row plant distance had the remarkable effect on the seed yield. Seed yield increased when narrow row spacing conducted and intra- row spacing decreased. The highest seed yield was achieved in 15 cm row spacing and 10 cm plant distance on the row. Application of this pattern can prevent inefficient usage of environmental potentials in low plant population under favorable condition and also, sever completion in high plant population under unfavorable condition.

REFERENCES

Azari, A. (2001): Determination of optimum planting pattern for safflower, variety Kooseh, at early and late planting dates in Isfahan. M.Sc. thesis. Department of Agronomy and Plant Breeding. Isfahan University of Technology. Isfahan, Iran (Iran Persian).

Beech,D. F. & Leach G.J.(1989): Comparative growth,water use and yield of chick pea ,safflower and wheat in southern Queensland,Australian Journal of Experimental Agriculture, 655-62.

Blackshaw, R.E. (1993): Safflower (Carthamus tinctorius) density and row spacing effects of competition with green foxtail (Setaris viridis). Weed Science, 41: 403- 408.

Board, J.E. (2004): Soybean cultivar differences on light interception and leaf area index during seed filling. Agronomy Journal, 96: 305- 310.

Cobley, A., Cozzeto, E. & Ventricelli, A. (1997): Performance of hybrid and open pollinated safflower in two different Mediterranean environment. International safflower conference. Italy.276-278.

Colton, R.T. (1988). Safflower growing. Agfact P5.2.2, Department of Agriculture, NSW, Australia.

Dadashi, N.A. (2001): Effect of planting date on yield and yield components of safflower cultivars. M.Sc. thesis. Department of Agronomy and Plant Breeding. Isfahan University of Technology. Isfahan, Iran (Iran Persian).

Elfadel, E. (2007): Effect of nitrogen rate and seed density on safflower (Carthamus tinctorius L.) under low-input farming system. Crop Production Institute, University of Hohenheim: Germany.

Esendal, E. (1986): The effect of phosphorus, nitrogen and row-spacing on the yield and some plant characters of the safflower. Sesame and Safflower Newsletter, 2: 96-98.

Esmi, R. (1997): Between and within row spacing effects on yield, yield components and other agronomic characterics of two spring safflower cultivars in Isfahan. M.Sc. thesis. Graduate School. Islamic Azad University. Khorasgan Branch. Isfahan, Iran (Iran Persian).

Gan, Y.T., Miller, P.R., McConkey, B.G., Zentner, R.P, Liu P.H. & Mc Donald, C.L. (2003): Optimum plant population density for chickpea and dry pea in a semiarid environment. Canadian Journal of Plant Science. 83: 1- 9.

Gencer O., Sinan, M.S., Gulyasar, F. (1987): A research on different row spacings of safflower which grown under unirrigated conditions of Cukurova region. J. of Cukurova Univ., Faculty of Agriculture, 2: (2) 54-68.

Gonzalez, J.L., Schneiter, A.A., Riveland, N.R. & Johnson, L. (1994): Response of hybrid and openpollinated safflower to plant population. Agronomy Journal, 86: 1070- 1073.

Jelali, A.H. & Bahrani, M.J. (2001): Planting pattern of three safflower cultivars in southern Iran. Shiraz University. www.sidney.ars.usda.gov / state / saffcon /abstracts /production management /bahrani.htm.

Johnson, B.L. & Hanson, B.K. (2003): Row-spacing interactions on spring canola oerformance in the in Northern Great Plains. Agronomy Journal, 95: 703-708.

Hoag, B.K., Zubriski, J.C., Geiszler, G.N. (1968): Effect of fertilizer treatment and row spacing on yield, quality and physiological response of safflower. Agronomy Journal, 60: 198-200.

Khadem Hamzeh, H.R. (1995): Determination of the best planting density for soybean (CV. Hbbit) at different planting dates. M.Sc. thesis. Department of Agronomy and Plant Breeding. Isfahan University of Technology. Isfahan, Iran (Iran Persian).

Knowles, P.F. & Miller, M.D., (1965): Safflower. California Agricultural Experiment Station, Extension Service, Circular 532, p.51.

Koutroubas, S.D., Papkosta, D.K. & Doitsinis, A. (2004): Cultivar and seasonal effects on the contribution of preanthesis assimilates to safflower yield. Field Crop Research (2004):1-12.

Materechera. SA, Alston. A.M., Kirby, J.M, & Dexter, A.R. (1993). Field evaluation of laboratory techniques for predicting the ability of roots to penetrate strong soil and of the in¯uence of roots on water sorptivity. Plant and Soil 149: 149±158.

Mohammadi, M. (1999). Effects of row spacing and seed density on the grain yield of barley in dryland condition. Seed and Plant. 15: 1-8.

Mohammadi, M. & Ghaffari A.A. (2009): Important option for crop rotation in warm dryland regions. II Oilseed and Pulses. Zeitoon. 244: 21-25.

Morrison, M.J., Mc Vetty, P.B.E. & Scarth, R. (1990): Effect of row spacing and seeding rates on summer rape in Southern Manitoba. Canadian Journal of Plant Science, 70: 127- 137.

14. Morrison, J.E., Rickman, R.W. & Pfeiffer, K.L. (1997): Measurement of wheat residue cover in the great plain and pacific Northwest. Agriculture, Ecosystems and Environment, 39: 187-196.

Mundel, H.-H., Blackshaw, R.F., Byers, J.R., Huang, H.C., Johnson, R., Keon, D.L., Kubik, J., McKenzie, R., Otto B., Roth B. & Stanford, K. (2004): Safflower production in the Canadian Prairies. Agriculture and Agri-Food Canada. Lethbridge Research Centre, PO Box 3000, Lethbridge, Alberta T1J 4B1. Canada.

Naseri, R., Fasihi, Kh., Hatami A. & Poursiahbidi, M.M. (2010): Effect of planting pattern on yield, yield components, oil and protein contents in winter safflower cv. Sina under rainfed conditions. Iranian Journal of Crop Science, 12(3): 227-238.

Nasr, H.G., Kakhuda, N. & Tannir, L. (1978): Effect of N fertilization and population rate-spacing on safflower yield and other characteristics. Agronomy Journal. 70: 683- 685.

Özel, A., Demirbilek T., Çopur, O., Gur, A., & Tarihi, G. (2003): The effect of different sowing date and intra-row spacing on petal yield and some agronomic characters of safflower (Carthamus tinctorius L.) under the Harran plain arid conditions. Journal of the Agricultural Faculty. Harran University, 8 (3/4):1-7.

Patel, Z.G., Menta, S.C. & Roy, V.C. (1994): Response of safflower to row spacing and nitrogen and phosphorus fertilizers in vertisol of south Gujarat. Indian Journal of Agronomy, 39: 699-700.

Qayyum, S.M., Rajput, M.A., Sodhro, T.M., Tunio K.D.L., Khan, W.A. (1986): Effect of different row spacing on the growth and yield of safflower. Sesame and Safflower Newsletter, 2: 74-82,

Robertson, M.J., Holland, J.F. & Bambach, R. (2004): Response of canola and Indian musterd to sowing date in the grain belt of north-eastern Australia. Australian Experimental Journal of Agriulture., 44: 43-52.

Salera, E. (1996): Yield and quality of safflower (Carthamus Tinctorius l.) at different populations and row spacing . Agricoltura Mediterranea , 126: 354-363.

Uslu, N., Akin A. & Halitigil M.B. (1998): Cultivar, weed and row spacing effects on some agronomic characters of safflower (Carthamus tinctorius L.) in spacing planting. Turkish Journal of Agriculture and Forestry. 22: 533- 536.

Van Hoorn, J.W. (1991): Development of soil salinity during germination and early seedling growth and its effect on several crops. Agricultural Water Management., 20: 17–28.

Weiss, EA. (2000): Oilseed Crops. 2nd ed. Oxford: Blackwell Science.

Yau S.K., (2009): Seed Rate Effects on rainfed and irrigated safflower yield in eastern Mediterranean. The Open Agricultural Journal. 3:32-36.

Zareian, A. (2001): Yield, yield components and growth characterstics of safflower genotypes under varying plant densities. M.Sc. thesis. Department of Agronomy and Plant Breeding. Isfahan University of Technology. Isfahan, Iran (Iran Persian).

Mohtasham MOHAMMADI and Rahmatollah KARIMIZADEH

REAGOVANJE ŠAFRANIKE NA RAZMAK IZMEĐU REDOVA BILJAKA I RAZMAK U REDU U UMJERENO TOPLIM I SUŠNIM USLOVIMA

SAŽETAK

Da bi se postigao najviši prinos šafranike, osim optimalnog razmaka između redova, od velikog je značaja odgovarajući raspored biljaka u redovima. Ovo istraživanje je sprovedeno na dijelu parcele, po planu slučajnog blok sisitema, u tri ponavljanja.

Razmak između redova (15, 30, 45 i 60 cm) i gustina biljaka unutar redova su locirani na vertikalnim i horizontalnim parcelama posebno. Istraživanje je sprovedeno na Poljoprivrednoj istraživačkoj stanici Gachsaran, upotrebom PI537598 (sorta Sina). Najveći prinos (812 kg/ha), dobijen je kod razmaka između redova od 15cm, ali maksimalan broj glavčica po biljci (12,1 cvijet) i broj zrna po glavčici (12,6 zrna) dobijeni su kod razmaka između redova od 60cm. Razmak između biljaka u redovima je značajno uticao na prinos zrna kao i na većinu komponenti prinosa. Rastojanje od 10cm je dalo najveći prinos (830 kg/ha), ali maksimalan broj glavčica po biljci (11,7 glavčica) i broj zrna po glavčici (12,9 zrno) ostvaren je u redovima sa razmakom od 40cm između biljaka. Različiti uslovi nisu uticali na težinu hiljadu zrna. Dakle, najveći prinos je ostvaren u uslovima 10×15 cm i nije bilo nikakvog uticaja rastojanja između redova i rasporeda biljaka u redovima. Utsak je da se velikom populacijom biljaka kompenzuje smanjenje komponenti prinosa i proizvedi više zrna, odnosno povećava prinos ulja.

Ključne riječi: suša, raspored biljaka, komponente prinosa, potencijal sredine