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Effect of Geographical Cultivating Directions and Density of Bulbs on Yield and Yield Components of Saffron (*Crocus sativus* L.) in Dry Land Farming condition in Damavand

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ABSTRACT: Effects of plant density and Geographical cultivating direction on saffron (*Crocus sativus*) yield and yield components were studied in dry land condition in 2014-2015 using a split plot experiment in the form of a randomized complete block design with six treatments, three replications and 18 plots in the Hamand Experimental Station of the Research Institute of Forest and Rangeland, Damavand, Iran. According to the variance analysis, density of bulbs, cultivating direction and their interaction revealed significant effects on different traits. The north-south direction caused maximum yield of stigma 1129.4 ($g.ha^{-1}$). Also density of 45 bulbs per m^2 led to additive effect on yield of stigma (1103.2 $g.ha^{-1}$). The interaction of 45 bulbs density with north-south cultivating directions had maximum average of yield of stigma (1483.2 $g.ha^{-1}$). This research demonstrated that density of bulbs along with cultivating direction affects performance of saffron cultivated in dry land conditions and higher yield is achieved at north-south direction.

Keywords: Saffron performance, density, cultivating direction, dry land.

INTRODUCTION

Reductions of Water is most limiting factor in arid and semi-arid areas and make balancing between water resources and water of plants is main factor to increasing plants production efficiency. Thus the water resources management requires the maximum water productivity per unit. Selection and cultivation of resistant medicinal plants to dry conditions are one of the important components of development and production of medicinal plants as the alternative cultivation systems for annual crops. The vegetation of perennial medicinal plants could prevent of soil Erosion which is made by annual plowing. Promoting of dry land farming of medicinal plants in sloping agricultural land and other kinds of farm lands can cause an improvement in the maintenance and restoration of dry land farming systems (Lebaschi 2008). *Crocus sativus* L. (saffron) is a Perennial plant without stems which is member of the Iridaceae family. Iridaceae contain 9 species in Iran include saffron. Saffron is an important spice which is cultivated in different regions of Iran. Saffron is an herbaceous and perennial plant with underground stems and bulbs. Scientists have categorized saffron in 8 species as ornamental groups (Jo-Ghasem, Ziba, Sefid, Almeh, Zagros, purple and Caspian saffron) and one species as crop saffron. Most species of ornamental saffron flowers in early spring while crop species flower in early autumn (Mozaffarian, 1996 and Abdullaev 2006).

The saffron spices prepare from its stigma and saffron reproduction make by bulbs (Vurdu *et al.* 2004).

Studies showed meaningful Differences in dry stigma yield of saffron in different density of cultivated bulbs (15, 30 and 45 bulbs per m^2) along with other treatments such as mulch, Weeding and using of herbicide. Investigation have recognized interaction of black plastic mulch with 45 per m^2 density of bulbs results maximum mean of dry stigma performance with 1485 $g.ha^{-1}$ while using of weeding and herbicide along with 15 per m^2 density of bulbs showed minimum mean of stigma yield of saffron with 533 and 613 $g.ha^{-1}$ respectively (Najafi Ashtiani and Lebaschi 2014). Also Emam *et al.* (2012) reported increasing planting density could increase economic performance of saffron. The objective of this study was to study the effect of geographical directions and density of saffron cultivation on yield and yield Components in Dry land farming in Damavand.

MATERIALS AND METHODS

A split plot experiment in the form of a randomized complete block design with six treatments and three replications and 18 experimental plots was conducted in the Hamand Experimental Station of the Research Institute of Forest and Rangeland, Damavand, Iran during the growing season of 2014-2015. The Bulbs density as main factor in 3 levels (15, 30 and 45 bulbs per m^2) and the Geographical cultivating directions in two levels (north-south direction and east-west direction) as sub factor were determined (Fig. 1).

Agricultural operation such as Tillage, saffron bulbs preparing and sorting and planting bulbs in rows were implemented according to planning program and density. Flower harvest began in early November. Harvesting operation was accomplished in every morning until the end of flowering with respect to margins of all four sides in each plot.

Stigmas After removal were placed in clean Petri dishes and were dried in oven at 40°C for 24 hours. Respectively the dry weight was measured. Performance of Morphophenological traits such as plant height, number of flowers, weight of flowers and yield of stigma were studied.

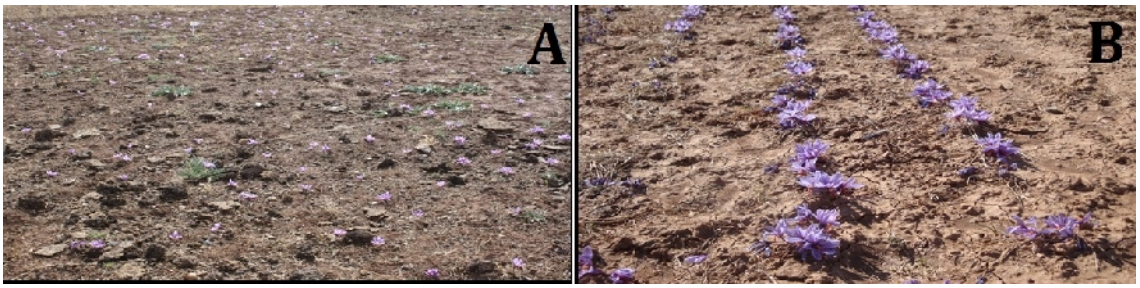

Fig. 1. Geographical cultivating directions. A: east-west direction. B: north-south direction.

RESULTS AND DISCUSSION

Analysis of variance (Table 1) indicated the significant effect of Geographical cultivating directions on plant height, number of flowers, weight of flowers and yield of stigma (P≤0.01). Also results showed which different levels of bulbs density had meaningful effects on weight of flowers and yield of stigma (P≤0.01) while plant height and number of flowers didn't show any meaningful differences. The interaction of bulbs density × cultivating directions had also significant effect on plant height (P≤0.05) and weight of flowers (P≤0.05) but no effect on number of flowers and yield of stigma were observed.

The results of mean Comparison for cultivating directions (Table 2) indicated that north-south direction had increasing effect on plant height (20.88 cm), weight of flowers (66.89 kg.ha^{-1}) and yield of stigma 1129.4 (g.ha^{-1}) while east-west direction showed minimum averages for mentioned traits (12.81 cm, 34.89 kg.ha^{-1} and 587.6 g.ha^{-1} respectively). However the east-west direction caused maximum average for number of flowers (3540).

The mean Comparison of Bulbs density (Table 3) showed that all levels of treatment include 15, 30 and 45 bulbs per m^2 were classified in one group (15.55, 16.67 and 18.17 cm respectively). Same results were obtained for number of flowers (3202.3, 3540 and 3386.3 respectively) which showed no significant statistical differences between these levels of bulbs density. However density of 45 bulbs per m^2 led to additive effect on other traits include weight of flowers (67.42 kg.ha^{-1}) and yield of stigma (1103.2 g.ha^{-1}) but levels of 15 and 30 bulbs per m^2 revealed no significant statistical differences for weight of flowers (40.72 and 44.53 kg.ha^{-1} respectively) and yield of stigma (658 and 814.4 g.ha^{-1}).

Table 1: Analysis of variance of studied saffron traits.

SOV	df	Mean Squares (MS)			
		Plant height	Number of flowers	Weight of flowers (kg)	Yield of stigma
Block	2	1.31	58610	4608	39074
Bulbs density	1	10.34^{ns}	171488^{ns}	1251.1**	305986**
Geographical cultivating directions	2	285.61**	1926030**	257.1**	1320980**
Bulbs density*Geographical cultivating directions	2	7.12*	24504^{ns}	366.6*	53618^{ns}
Error	10	3.72	115152	66.9	31288
CV (%)	-	146	0.57	0.17	4.45

ns, non significant; *, significant at P≤0.05; **, significant at P≤0.01.

Table 2: The mean Comparison of Geographical cultivating directions.

Cultivating directions	Plant height	Number of flowers	Weight of flowers (kg)	Yield of stigma
north-south	20.78a	3386.3a	66.89a	1129.4a
east-west	12.81b	3540a	34.89b	587.6b

Table 3: The mean Comparison of Bulbs density.

Bulbs density	Plant height	Number of flowers	Weight of flowers (kg)	Yield of stigma
15	15.55a	3202.3a	40.72b	658b
30	16.67a	3540a	44.53b	814.4b
45	18.17a	3386.3a	67.42b	1103.2a

Table 4: The mean Comparison of interaction between Bulbs density and Geographical cultivating directions.

Interaction	Plant Height	Number of Flowers	Weight of Flowers (Kg)	Yield of Stigma
north-south*15	19.33a	2948.3a	50.63bc	873.2bc
north-south*30	19.67a	3185a	57.8b	1031.9ab
north-south*45	23.33a	3014a	92.23a	1483.2a
east-west*15	11.77b	3456.3a	30.8c	442.9c
east-west*30	13.68b	3895a	31.27c	596.9bc
east-west*45	13b	3857.7a	42.6bc	723.1bc

The results of mean Comparison for interaction of bulbs density × cultivating directions revealed that north-south direction along with 45 bulbs density have maximum average of plant height (23.33 cm) and Following that interaction of north-south × 30, 15, east-west × 30, 45 and 15 bulbs density showed respectively maximum to minimum averages (19.67, 19.33, 13.68, 13 and 11.77). The maximum average of flower numbers belonged to interaction between east-west cultivating direction and 30 bulbs density per m^2 with 3895.

The mean Comparison also represented that interaction of 45 bulbs density per m^2 × north-south cultivating directions have maximum average of weight of flowers (92.23 $kg.ha^{-1}$) and yield of stigma (1483.2 $g.ha^{-1}$). After that interaction between north-south direction × 30 and 15 bulbs density showed maximum average of weight of flowers (57.8 and 50.63 $kg.ha^{-1}$) and yield of stigma (1031.9 and 873.2 $g.ha^{-1}$). Also minimum averages of weight of flowers (42.6, 31.27, and 30.8 $kg.ha^{-1}$) and yield of stigma (723.1, 596.9 and 442.9 $g.ha^{-1}$) respectively were related to interaction between east-west direction × 45, 30 and 15 bulbs density.

Results of variance analysis and mean of comparison emphasized that geographical cultivating directions and density of bulbs have significant Morphophenological effect on yield and yield components of saffron (*Crocus sativus*) in dry land farming condition of Damavand region. Also meaningful differences were observed between studied traits which indicate saffron sensitivity to direction of cultivation and bulbs density in dry land farming condition. As results showed the weight of flowers in north-south direction was 66.89 $kg.ha^{-1}$ while weight of flowers in east-west direction was 34.89 $kg.ha^{-1}$. The densities of 45, 30 and 15 bulbs per m^2 have revealed 67.42, 44.53 and 40.72 $kg.ha^{-1}$ of flowers weight. Also this study indicated north-south direction caused maximum yield of stigma 1129.4 ($g.ha^{-1}$) while east-west direction showed minimum averages (587.6 $g.ha^{-1}$) of stigma performance. The interaction of 45 bulbs density with north-south cultivating directions has maximum average of yield of stigma (1483.2 $g.ha^{-1}$). The influence of climatic factors such as prevailing winds which generally blow from West to East can make the significant differences in saffron performance. Wind blowing across north-south direction lines of cultivated saffron can cause more moisture absorbs by green leaves which increase plant growing.

The results of this study are similar to other reports which studied the effect of bulbs density on saffron performance. Najafi Ashtiani (2014) showed application of different density of bulbs along with fertilizer have significant effect ($P \leq 0.01$) on number of flowers, The ratio of style weight to stigma weight, number of stigma and weight of stigma. Also the mean of comparison identified 45 bulbs density per m^2 had maximum increasing effect on saffron yield as resulted 286019 flowers in hectares while 15 bulbs density per m^2 caused 175741 flowers in hectares (Najafi Ashtiani, 2014). Emam *et al.* (2012) studied effect of planting density with different levels of nitrogen and phosphor fertilizer application on saffron performance. They showed significant effect of planting density and nitrogen fertilizer application on all measured traits except for the length of the stigma and length of the white and red parts of stigma. They indicated that average flower fresh weight and fresh stigma weight were highest in the interaction of the highest planting density and using of 75 kg nitrogen and phosphor fertilizer per hectare. Hosseinzadeh *et al*. (2006) also studied 3 levels of plant density include 20, 30 and 40 per m^2 with 60 cm distance line culture on characteristics of *Dracocephalum moldavica* and they observed that density had not meaningful effect on Essential oil percentage however essential oil of single plants increased in low density.

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