Experimental Findings of Production and Echo Physiological Aspects of Saffron (*Crocus sativus* L.)

Abdollah Mollafilabi
Khorasan Sci. & Tech. Park (KSTP)
P.O.BOX 91735-139, Mashhad
Iran

Keywords: corm, fertilization, irrigation, nutrition, physiology, weeding

Abstract

Saffron (*Crocus sativus* L.) has devoted more than 40,000 ha cultivation surface area in Khorasan representing more than 97% of total production in Iran. This plant has a particular position among field crops due to its low water requirement, maintenance of permanent jobs, exports, and exchange increase. The agricultural economics of some of cities of Khorasan is highly dependent of saffron cultivation.

Herein, the influence of physiological, environmental and cultural factors on saffron production, such as temperature, soil, corm size, planting date, plant density, method of planting, irrigation, fertilization, and weed control, based on both traditional and scientific knowledge are commented, adding some recommendations for efficient saffron cultivation.

INTRODUCTION

Saffron (*Crocus sativus* L.) has devoted 43,408 ha cultivation surface area in Khorasan and its production is 127t (97.6 % of total production in Iran). This plant has a particular position among field crops due to its low requirement of water, 57,000 permanent jobs, exports (120t in 2001) and exchange increase (on the average, 500 $ every kg saffron). In other words, agricultural economics of some of cities of Khorasan is highly dependent to saffron cultivation (400,000 persons earn their living from saffron).

Saffron has a growth length of 220 days, needs a mild winter but with enough snow and a dry and hot summer.

This paper review has been written from native knowledge and research findings conducted in Iran and other parts of the world that can be read about ecophysiological and cultural management factors effective in Saffron production for those who are interested about this crop.

LITERATURE REVIEW AND RESEARCH FINDINGS OF SAFFRON IN IRAN

Temperature

Javanmard et al. (2002) have reported –18°C as the maximum coldness tolerance, but saffron landraces in Torbate Hydarieh tolerate up to 22°C, even though severe coldness causes saffron yield to be reduced. Minimum temperature induces flowering during this period. In colder areas saffron flowering occurs earlier (Kamali, 1988). About heat tolerance, the author has not observed any published matter, but repeatedly the author has observed a close relation between rate of leaf drying and air temperature in spring.

In southern Khorasan, during leaf greening of saffron, maximum absolute temperature does not reach above 30°C; nevertheless, resistance of this plant has been estimated up to 40°C. But, determination of threshold of leaf growth suppression and limit temperature of leaf survival requires additional extensive research (Vafabakhsh et al., 2002).

Soil

Soil of saffron farm must be loamy with suitable permeability. Saffron grows well

in salty, clay sand, rich in Fe and plaster soil in soils rich in Ca where organic matter is well decomposed (Abbasi, 1997). Such soils are recommended for saffron. Barshad et al. (1956) suggested that calcium carbonate deficiency of soil could be considered as the limiting factor. It has been proved that the presence of calcium carbonate can be synergistic for trace elements (Madan et al., 1966). Shahandeh (1990) under an extensive evaluation in 30 farms of saffron in Gonabad, studying the relation between saffron yield and physico–chemical properties of soil and irrigation water, concluded that although fertilizer requirement of saffron plant is low, 16 to 18% of fluctuations in yield of saffron flower is related to soil features, and 1 to 10% to water variables that effective factors of soil. These are content of organic matter, available phosphorus, mineral nitrogen, exchangeable K and C/N, respectively. Ammonia N of soil has negative effect on flower yield and increasing No3-–N of soil has positive effects.

Important aspects of management in technology of saffron production are crop rotation, choice and preparation of the land, methods of planting, corm selection, date of corm planting, corm preparation for planting, plant density, irrigation, fertilization, weed control and weeding, time and method of harvesting flowers. Some research findings and native knowledge in Iran are considered as follows.

Selection and Size of Corm

In selecting corm, 2 to 4 years-old corms and between them large ones and with healthy buds are used. Applied results obtained from experimentation conducted by Sadeghi (1993) and Latifi et al. (1996) during several cropping years, have shown that corms above 8 gr have a high rate of flowering during the first three years, therefore in the first year 3.5 kg, in the second year 11 kg and in the third year 20 kg dry saffron/ha are produced. A three-year average has been proved to produce two–fold that of traditional farms of Khorasan. In Chubathia Experimental Station, in the state of Uttar Pradesh in India, it has been shown that increasing corm diameter has positive effect on percent of flowering and number of saffron leaves. Planting corms above 3 cm diameter with approximately weight of 10 gr. has been recommended.

Planting Date

Saffron is planted predominantly late from July to late September in Khorasan. Sadeghi (1993) in a work dealing with ‘corm storage and its planting date on saffron flowering in two areas of Ghaen and Mashhad during two cropping years’ concluded that the best time for planting and displacement of saffron corms to new farms is from mid–may and especially early in June. In the first year of planting a harvest of 2.8 kg/ha dry saffron can be obtained. With respect to saffron plant physiology, development stages and differentiation of organs in saffron corm the best time of displacement and planting corm is recommended to be in early-June.

Plant Density (no. of Corms)

Plant density depends on the method of planting, native knowledge of farmers and size of corm. On the basis of some investigations conducted in different areas of saffron cultivation in Iran, Alavi et al. (1994) and Ghalavand and Abdollahian (1994) recommended an optimum plant density of 50 plants/m^2 with row and plant distance (20 10) and (30 10) and above 8 gr corms for maximum yield 4 to 5 tons/ha.

Method of Planting

In Iranian traditional cultivation, saffron corms are planted in a hole but rarely in furrow. With this method of planting row distance is from 30 to 35 cm, hole distance 25 cm and number of corms in each hole from 3 to 15. According with experimental results, row planting in the form of single corm is recommended. Recently, Iranian researchers have designed a two–row planter of corm for plant distances of 7 to 15 cm, row distance of 20 cm and depth of 15 cm. Planting pattern of a single corm in rows yields corm weights about above 8 gr (Saeidi Rad, 2001). Therefore, pattern of dense planting single

corm in rows is recommended.

Irrigation

On the basis of native knowledge, farmers in Khorasan irrigate saffron farms four times per crop season. First irrigation takes place before furrowing and crusting of land surface with the purpose to allow growth starting and facilitate flowering. Second irrigation occurs after flower harvest and leaves emergence. Third irrigation is applied after weeding and fertilization, and the fourth and last one at the end of the growing season (early in May). In farms of saffron in Khorasan, summer irrigation is not conventional, but Sadeghi (1988), in a series of experiments carried out during two cropping years in these area, found out that one irrigation early in august in newly planted and in perennial saffron crops, increase flower yield 17% and 40%, respectively.

Mosaferi (2001), during two-years studies in Mashhad, supported this result and suggested that water requirement of saffron annually is about 3000 m^3.

Shirmohammadi (2003) suggested that growth duration of elementary development, mid and final stages are 30, 55, 105 and 30 days, respectively and plant coefficients in these stages are 0.4, 0.85 and 0.55. The best time for the first irrigation is 7th October due to air temperature in Khorasan. The reported most suitable irrigation interval is 15 days.

Fertilization and Nutrition

Experiments conducted in Iran about fertilization, soil, water and time of absorption of macro and micronutrients in saffron plant; show that this plant needs low amounts of nutrients. If in addition to flowers, saffron leaves are harvested, for each ton of leaves, 10.2 kg N, 3.2 kg P and 22.83 kg K are removed from soil (Kianmehr, 1984). Researchers have observed that an increase of more than 100 kg urea/ha reduce saffron yield. Moreover, when compound fertilizer is used, via leaf spraying, two or three times in winter, yields increase relative to controls but in a lower rate that when a single treatment is used. As a whole, it has been suggested that in spreading fertilizer especially N fertilizer, we must pay attention to organic matter content and other variables. 100 kg urea fertilizer after flower harvest or merely 25 tons manure or fertilizer spraying once late in winter, with compound liquid fertilizer (12% N, 7% P2O5, 4% K2O + Fe, Zn, Mn & Cu chelates) at concentration of 7 /1000, and on the basis of 1000 lit water/ha, are recommended (Sadeghi et al., 1988; Sadeghi, 1989; Behnia, 1994; Hosseini, 1997).

Weed Control and Weeding

In traditional methods weeding in saffron farms is applied once or twice per crop season (Kafi, 2002). In Iran 184 species of weeds grow in saffron farms; 20 of them are dominant, and between them *Fumaria*, *Bromus*, *Setaria*, and *Brassica* are present (Rashed mohasel, 1990; Abbasi, 1997). Broad–leaved weeds are pre–emergence and post–emergence controlled by Sencor (Metribuzin) and narrow–leaved weeds by Gallant (Haloxy fopetoxy–ethyl) after flower harvest. Pre–emergence treatment with Sonalan (Ethyl fluralin) along with crusting are recommended (Raje and Mobaein, 1988; Amiri et al., 1990; Rahimian mashadi, 1993; Abbasi, 1997). For control of summer weeds simultaneously with saffron dormancy, the general herbicides Roundup (Glyphosate) and 2,4–D are applied (Behnia, 1991).

RESULTS AND RECOMMENDATIONS

Saffron yield average per year in Iran during a 25-year period has been of 4.7 kg. Duration of flowering in Iran reaches 8 years, having low yield in the first years and the highest yield in years 4 and 5 (Sadeghi, 1993; Behnia, 1994; Lafiti et al., 1996; Kafi et al., 2002). Using new methods of cultivation and the application of research results will lead to a shortening in crop cycle from 8 to 4-5 years, with a three-fold increment in yield of the present average in Iran. For approaching this purpose, it is required a physically and chemically appropriated planting bed, as well as the provision of healthy and vigorous

corms from young farms. These corms must be graded and selected; those with more than 8 gr corms should be disinfected by fungicide early in June, and planted on the basis of dense plantations (50 plants/m2) in the form of one corm in rows. Irrigation interval due should be applied in intervals of 15 to 25 days on the basis of plant requirements and weather conditions. The rate of fertilizer must be established attending to soil analysis and other climatic and environmental factors. 100 kg/urea 46% after flower harvest together with the second irrigation or spraying with compound fertilizer 7 /1000 late in winter, at only once application is recommended.

If possible, application of manure at 25 tons/ha has a considerable effect on physico-chemical and biological properties of soils and crops, and is preferred to chemical fertilizer. Saffron plant is almost an organic crop and weed control made by hand is encouraged. But, if the crop becomes chemical, recommended herbicides with respect to time and concentration and control in summer is emphasized.

Literature Cited

Abbasi, M.A. 1997. Effect of different herbicides on weeds of southern Khorasan. M.S. Thesis. Ferdowsi University of Mashad.

Alavi, H; Mohajeri, M. and Falaki, M.A. 1994. Evaluation of plant density on saffron yield. Proceedings of 2nd Seminar on Saffron and Cultivation of Medicinal Plants. Gonabad, Iran.

Amiri, H. 1990. Effect of herbicides in control of saffron farms in Southern Khorasan. Agricultural Research Center of Khorasan Press, Iran.

Barshad, I, Halevy, E., Gold, H.A. and Hagin, G. 1956. Clay minerals in some limestone soils from Israel. Soil Sci. 81: 423-437.

Behnia, M.R. 1991. Saffron Cultivation. Tehran University Press, Iran.

Behnia, M.R. 1994. Effect of different levels of chemical and animal fertilizer in Saffron yield. Proceedings of 2nd Seminar on Saffron and Cultivation of Medicinal Plants. Gonabad, Iran.

Ghalavand, A. and Abdollahian noghabi M. 1994. Ecological adaptation and study of spacing and method of planting on yield of different landraces of Iranian saffron. Proceedings of 2nd Seminar on Saffron and Cultivation of Medicinal Plants. Gonabad, Iran.

Hosseini, M. 1997. Effect of foliar fertilization on saffron yield. I.R.O.S.T. Mashhad Center, Iran.

Javanmard, S., Ahmadian, J., Malboosi, Sh. and D. Dashtbani. 2002. Comparison of risk evaluation of saffron cultivation in ecological units of Southern Khorasan. First Festival of Saffron. Ghaen, Iran.

Kafi, M. 2002. Saffron (Production Technology and Processing). Ferdowsi University of Mashhad, Iran.

Kamali, A. 1988. Bioclimatological studies of saffron in southern Khorasan. I.R.O.S.T. Mashhad Center, Iran.

Kianmehr, H. 1984. Endotrophic michorriza of saffron in Khorasan and possibility of its application. Proceeding of 2nd Seminar on Saffron and Cultivation of Medicinal Plants. Gonabad, Iran.

Latifi, N. and Mashayekhi, K. 1996. Effect of corm weight on saffron flowering. Proceeding of 4th Congress on Cultivation and Plant Breeding of Iran. Technology University of Esphahan, Iran.

Madan, C.L., Kapar, B.M. and Gupta, U.S. 1966. Saffron. Econ. Bot. 20.

Mosaferi, H. 2001. Effect of different regimes of irrigation on saffron yield. M.S. thesis of irrigation and drainage. Ferdowsi University of Mashhad, Iran.

Raje, M. and Mobaein, A. 1988. A preliminary investigation of different herbicides on weeds of saffron weeds. Proceeding of First Seminar on Saffron Problems. Ghaen, Iran.

Rashed mohasel, M.H. 1990. Identification of saffron weeds in Southern Khorasan. I.R.O.S.T. Mashhad Center, Iran.

Rahimian mashhadi, H. 1993. Effect of some chemical herbicides in control of saffron weeds. I.R.O.S.T. Mashhad Center, Iran.
Saeidi rad, M.H. 2001. Designing, manufacturing and evaluation of saffron corm planter. Agricultural Research Center of Khorasan, Iran.
Shahandeh, H. 1990. Evaluation of physico-chemical properties of water and soil in relation to saffron yield in Gonabad. I.R.O.S.T. Mashhad Center, Iran.
Shirmohamadi, R. 2003. Effect of light and amount of irrigation water on indices of leaf area, temperature of green cover and saffron plant yield. M.S. Thesis of Irrigation and Drainage. Shiraz University, Iran.
Sadeghi, B.1988. Effect of summer irrigation on saffron yield. I.R.O.S.T. Mashhad Center, Iran.
Sadeghi, B. 1989. Effect of chemical and animal fertilizers on leaf production, corm and economical yield of saffron. I.R.O.S.T. Mashhad Center, Iran.
Sadeghi, B.1993. Effect of corm weight on saffron flowering. I.R.O.S.T. Mashhad Center, Iran.
Sadeghi, B, Razari, M. and Mohajeri, M. 1988. Effect of different rates of chemical fertilizers in increasing saffron yield. Agricultural Research Center of Khorasan Press, Iran.
Vafabakhsh, J, Ahmadian, H, Sheibani, D. and Bodagh Jamali, J. 2002. Recognition of potential of cultivation areas of Saffron in Iran. First Festival of Ghaen, Iran.

Tables

Table 1. Comparison of total production for 8 years of flower and saffron in fertilizer treatments (kg/ha)

Site	Yield	N	P	K	Manure	NP	NK	PK	NPK
Torbat-e-Heydarieh	Flower	617	3272	3412	5420	5872	6124	3760	6080
Mashhad	Flower	5825	2332	2510	7078	6118	6071	2385	6393
Torbat-e-Heydarieh	Saffron	85	41.3	43	74.6	80.8	84.2	47.6	83.7
Mashhad	Saffron	80.2	29.4	31.7	94.4	84.2	83.5	30.1	88
Torbat-e-Heydarieh	Average	10.6	5.16	5.37	9.32	10.1	10.5	5.92	10.4
Mashhad	Annually	10	3.7	4	11.8	10.5	10.4	3.8	11

Figures

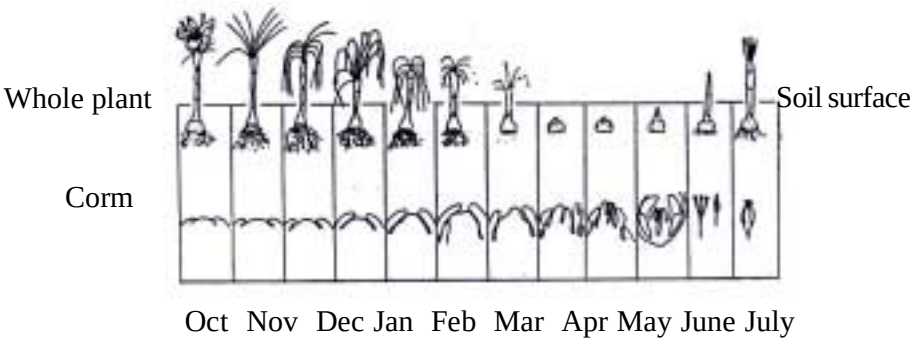

Fig. 1. Flower development and different stages of growth of saffron plant in a one-year period

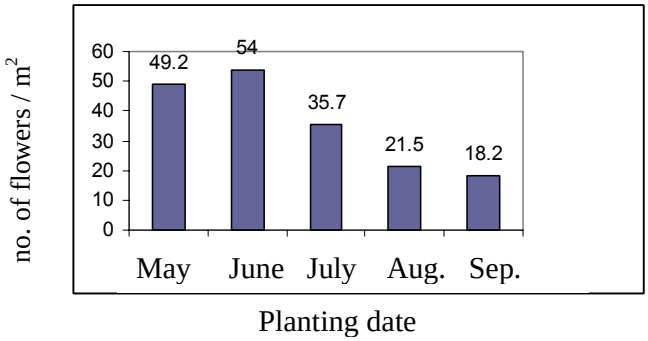

Fig. 2. Effect of saffron corm in flowering of the first year in Ghaen

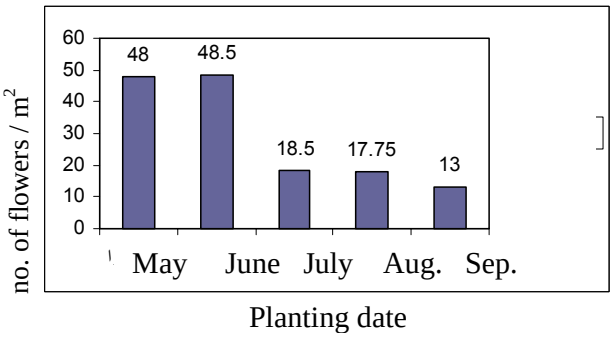

Fig. 3. Effect of saffron corm in flowering of the first year in Mashhad