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Full Length Research Paper

Respond of saffron (*Crocus sativus* L.) to animal manure application

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Yield of saffron (*Crocus sativus* L.), is the most expensive medicinal and spicy plant, which significantly respond to degree of soil fertility. In comparison to chemical Nitrogen (N) fertilizer, application of cow manure (20 to 30 t ha^{-1}) combined with chemical-N (23 kg/ha) to the soil surface increased significantly soil fertility. Saffron plant was treated with N as urea ($CO(NH_2)_2$, 46% N) at 50 to 100 kg ha^{-1}; and 20 to 30 t ha^{-1}; combination of urea (50 kg ha^{-1}) and cow manure (20 t ha^{-1}). Application of cow manure plus N fertilizers increased yield components of saffron. The highest yield (0.45 g m^{-2}) was obtained with the combination of cow manure and urea 50 kg ha^{-1}, and the lowest (0.24 g m^{-2}) with control. The maximum flower fresh weight (0.89 g), with the longest stigma (29 mm) were obtained in the combination of urea (50 kg ha^{-1}) + cow manure (20 t ha^{-1}) treatment, and the lowest (0.43 g) with control, respectively. The N application increased vegetative growth, but not significant on yield. Application of cow manure (20 to 30 t ha^{-1}) to the soil surface and mixed to 30 cm depth as soil amendments increased significantly (*P = 0.05*) soil organic matter (OM), soil electrical conductivity (EC), soil pH, and cation exchange capacity (CEC). There was a positive relationship between amounts of manure applied and soil in OM contents.

Key words: Saffron, nitrogen source, nutrient management, organic farm.

INTRODUCTION

The most expensive medicinal spicy plant in the Middle East countries is saffron (*Crocus sativus* L.). Saffron is widely used as a sedative and analgesic in traditional medicinal preparations (Sampathu et al., 1984; Winterhalter and Straubinger, 2000). Even, it has been shown recently that saffron has distinct anticancer activities (Nair et al., 1991; Rios et al., 1996; Abdullaev, 2002). This crop has a very low harvested yield (stigmas/biomass) (Negbi et al., 1989; McGimpsey et al., 1997; Benschop, 1993; Mollafilabi, 2003; Deo, 2003). Yield is significantly influenced by nutrient management t and cultural methods (McGimpsey et al., 1997; Deo, 2003; Fernández, 2004). Since, saffron is a perennial crop; it has been adapted to fertilizers, especially N fertilizers influence significantly on quantity and quality of yield (Amiri, 2008). It was stated that saffron culture, no further chemical fertilizer was applied to the crop, after initially applying 20 to 50 t ha^{-1} farm yard manure at planting and field is lifted even for 3 to 4 years under non-fertilizer conditions. But, quantity and quality of Table 1 spice yield production have remarkably declined in the following years (Behdani et al., 2005). Application of chemical fertilizers in infertile soil increased both yield (up to 15 kg ha^{-1}) (Sampathu et al., 1984; Dhar et al., 1988), and increased production of daughter corms (Behzad et al., l992; Rezaian and Forouhar, 2002).

In Kashmir, a survey of saffron fields showed higher yields of spice were collected from younger fields that generally had a higher soil nutrient status (Dhar et al., 1988), and corm production of ornamental *Crocus* species was enhanced by applying 40 to 50 kg N ha^{-1} (Benschop, 1993). Koocheki et al. (2006) found that 20 to 80% of saffron yield is attributed to soil fertility (C/N ratio, available phosphorus, mineral nitrogen, and exchangeable potassium). Mollafilabi, (2003) reported that up to 100 kg ha^{-1} ammonium phosphate has been used in some saffron fields, which encouraged vegetative growth and decreased the yield (Housini (2004). On the other hand, some others, traditionally have being applying a high amount of farmyard manure (animal

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Table 1. Influence of amount and kind of N fertilizers on yield components of saffron.

Treatment N-source	kg/ha	Fresh yield flower (g)	Stigma size (mm)	Stigmas weit. (g/flw)*	Stigmas yie. (g m^{-2})**
Control	0	0.43^{a}	19^{a}	0.022^{a}	0.24^{a}
N	23	0.61^{ab}	22^{b}	0.028^{a}	0.28^{b}
N	46	0.69^{ab}	20^{a}	0.029^{a}	0.28^{b}
Cow manure	20t	0.56^{b}	23^{a}	0.038^{b}	0.2^{b}
Cow manure	30t	0.63^{b}	24^{ab}	0.039^{b}	0.31^{bc}
N+ cow manure	23 kg+20t	0.89^{c}	29^{c}	0.052^{c}	0.45^{c}

*stigma fresh weight per flower (g); ** stigma dry weight as yield (g m^{-2}); M_n = 20 t h^{-1} cow manure. Mean separation within columns by Duncan's multiple range test at $P = 0.05$.

manures, straw and compost), as basic source of nutrients for the saffron crop, since centuries ago (Koocheki et al., 2006).

Application of organic fertilizers, as soil amendments or surface mulches, have been advocated as compatible with IAP (Integrated Agricultural Production) since fertilizer inputs can be reduced. It can be inferred that saffron nutrient demands could be supplied by application of enough animal manures. Evidences showed that application of 40 to 60 t ha^{-1} animal manure supplied not only nutrient requirements of plant, but also improved soil fertility. This lead to the minimizing of the use of chemical fertilizers (organic system), and consistently affected quantity and quality of saffron yield (Koocheki et al., 2006). These basic nitrogen sources are considered to be important for saffron production since they not only provide nutrients for plant growth, but also improve soil structure which increases corm multiplication, increasing saffron yield.

MATERIALS AND METHODS

This research was conducted in a Randomized Complete Block Design (RCBD) experiment, and each treatment has four replications, during two growth seasons. The treatments were: control (neither cow manure, nor chemical N fertilizer); actual net N 23 kg, actual net N 46 kg; cow manure 20 t; cow manure 30 t, and combination of N 23 kg + cow manure 20 t). Any treatment containing N received N as urea [$CO(NH_2)_2$, 46% N] at 50 kg ha^{-1} at two times; P as super phosphate [$Ca(H_2PO^4)_2$, 46% P_2O_5] at 40 kg ha^{-1}, that cow deep litter manure contained approximately moisture 75%, organic carbon 28%, ash 12% (DW), pH 5.9, Ca 0.78%, K 0.5%, P 1.3%, Mg 0.4%, Cu 32 ppm, Fe 340 ppm, Mn 67 ppm, and Zn 40 ppm. Cow manure was manually mixed into the top soil with a rake in the early spring. The soil composition was: sand 60%; silt 22%; clay 18%, limestone <5%, organic carbon (OC) = 0.4%, soil pH≥7.8, CEC = 4.2 meq100 g^{-1}, and EC = 2.1 *mS*cm^{-1}. Corms of saffron were planted in furrows formed with a plough, with corms placed about 10 cm apart along the row and about 15 cm deep, in June. The distance between the rows is about 25 cm. To omit interaction between agricultural practices and fertigation, the traditional practices (manual weed control, ground irrigation) were applied similarly for all treatments. Three time irrigation were similarly applied for all treatments. Weeds were controlled by hand, when needed. Saffron corms send up their narrow leaves and begin to bud in late September and there was flower in the plant.

Flowering was about 15 ±2 days and flowering harvesting was done at dawn during 2 weeks at the beginning of November. Stigmas were immediately separated from flowers by hand. Following the separation of the stigmas from the flowers, stigmas were immediately dried in hot room (final products with 14±2 % moisture). Flower fresh weight (g), stigma length (mm), stigma fresh weight (g $flower^{-1}$), and stigma dry weight (g m^{-2}) as yield were measured. To measure leaf mineral concentrations (DW %), about 20 to 30 leaves were sampled after yield harvesting (initially flowering in saffron plant) Table 1. Both soil and plant samples were oven dried at 60°C for 48 h and ground to pass through a 40 mesh screen, and were analyzed for mineral contents. Soil samples were analyzed for total N, ammonium N, P, S, organic carbon, Fe, E and pH (CaCl). All soil and plant samples were digested according to technique used by Sealed Chamber Digest (SCD) (Anderson and Henderson, 1986) Table 1. All data were subjected to analysis of variance procedures and means subjected to Lysergic acid diethylamide (LSD) test at $P=0.05$.

RESULTS AND DISCUSSION

The results of this research revealed that application of animal manures, the same as traditional farming, improved not only yield components of saffron, but also soil fertility. Both, yield and leaf nutrient status improved by the manure (especially, it combined with urea 50 kg ha^{-1}) application. Interestingly, no symptoms were observed in mineral deficiencies during the two growth seasons. Application of cow manure (20 t ha^{-1}) plus N (actual N 23 kg ha^{-1}) was more effective in increasing of saffron yield than application individual fertilizer N (Table 1). Beneficial effect was related to application of cow manure (20 t ha^{-1}), which improves soil fertility (nutrient retention capacity, water holding capacity, and C/N ratio). The highest average of flower fresh weight (0.89 g), with the longest stigma (29 mm) was obtained in the combination of chemical-N and cow manure (Table 1). The greatest average of stigma fresh weight (0.052 g $flower^{-1}$), and the highest average of yield (0.45 g m^{-2}) was obtained in the actual N (23 kg ha^{-1}) plus cow manure (20 t ha^{-1}) treatment, whereas, the lowest average of yield (0. 23 g m^{-2}) was recorded for control during experiment (Table 1).

Chemical N-fertilizer only increased mostly vegetative growth not reproductive growth. But N combined with cow

Table 2. Influence of amount and kind of N fertilizers on leaf nutrient concentration of saffron.

Treatment N-source	kg/ha	N (%)	P (%)	K (%)	Mg (%)	Ca (%)	B (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
Control	0	0.53^{a}	0.54^{a}	3.09^{a}	0.37^{a}	1.98^{b}	33^{a}	28^{b}	68^{a}	189^{a}	48^{a}
N	23	0.66^{b}	0.55^{a}	3.60^{a}	0.46^{a}	1.84^{a}	62^{b}	12^{a}	94^{b}	195^{a}	43^{a}
N	46	0.83^{c}	0.85^{b}	3.82^{a}	0.39^{a}	1.95^{b}	38^{a}	14^{a}	82^{b}	153^{a}	44^{a}
Cow manure	20t	0.60^{b}	0.60^{a}	4.04^{b}	0.57^{b}	1.51^{a}	36^{a}	13^{a}	90^{b}	195^{a}	41^{a}
Cow manure	30t	0.65^{b}	0.69^{b}	3.93^{b}	0.47^{b}	1.40^{a}	37^{a}	24^{b}	70^{a}	172^{a}	40^{a}
N+ cow manure	23kg+20t	0.96^{c}	0.61^{a}	3.58^{a}	0.35^{a}	1.72^{a}	36^{a}	32^{b}	76^{a}	163^{a}	52^{a}

Mean separation within columns by Duncan's multiple range test at P = 0.05.

Table 3. Effects of a range of cow manure and chemical N-fertilizer application on soil nutrient content and chemical properties of a saffron farm.

Treatment N-source	kg/ha	CEC meq*	OC %	pH H_2O	EC mS**	NO_3^- μg/g	NH_4^+ μg/g	P %	Ca %	Mg %	K ppm	Fe ppm
Control	0	4.2^{a}	0.4^{a}	7.5^{a}	2.1^{a}	33^{a}	14^{a}	2.3^{a}	1.9^{a}	0.51^{a}	230^{a}	31.8^{b}
N	23	8.6^{a}b	1.3^{b}	7.4^{a}	2.2^{a}	45^{b}	15^{a}	2.2^{a}	2.1^{a}	0.45^{a}	450^{b}	20.2^{a}
N	46	14.5^{b}	1.1^{b}	7.3^{a}	2.4^{a}	84^{c}	21^{b}	2.5^{a}	2.8^{b}	0.56^{a}	585^{c}	24.2^{a}
Cow manure	20t	11.5^{b}	2.2^{c}	7.2^{a}	2.6^{a}	43^{b}	13^{a}	2.3^{a}	2.2^{b}	0.65^{a}	620^{c}	23.0^{a}
Cow manure	30t	17.1^{c}	3.7^{d}	6.8^{b}	3.2^{b}	88^{c}	20^{b}	2.5^{a}	2.8^{b}	0.75^{b}	780^{d}	28.2^{b}
N23 kg + cow manure	20t	13.6^{b}	2.1^{c}	7.1^{b}	3.1^{b}	93^{d}	24^{c}	2.9^{a}	2.1^{c}	0.85^{b}	830^{e}	34.2^{c}

*meq100g^{-1} soil, ** *mS*cm^{-1}, Mean separation within columns by Duncan's multiple range test at *P=0.05*.

manure could be well utilized by the plants and increased quantity and quality of yield (Table 1), because of more nutrient availability in the soil, in other words, soil nitrogen levels increase and providing a balance of other nutrients and improved soil moisture status (Table 3). Comparison to non fertilizer conditions (control) that results in less and shorter period flowering with small stigmas. Leaf mineral concentrations increased by the cow manure application. Leaf mineral concentrations (% dry weight DW) were quite adequate for all elements (Table 2). No symptoms were observed in mineral deficiencies during growth seasons. Relationships between leaf tissue mineral concentrations and yield components were completely different for each treatment. Soil fertility management for saffron production can be mainly based on combination of different animal (sheep, cattle, horse and chickens) manures with an appropriate amount of chemical (N, phosphorus (P), potassium (K)) fertilizers. For example, some farmers keep their domestic animals (sheep and cattle) in their saffron fields during late spring and summer. This improves soil fertility, but it can not supply all of nutrient requirements for the saffron growth. It is better animal manure (20 t ha^{-1} cow manure) combined with macronutrients (P, N) for higher nutrient use efficiency and results (flowering and vegetative growth) (Table 1).

From results of this project, it can be said that application of cow manure (20 t ha^{-1}) alone can not adequately supply saffron nutritional necessities, but it improves physical and chemical properties of soil and increase soil nutrient and water-holding ability and indirectly crop production. These basic nutrient sources are considered to be important for quality saffron production.

It can be said that the effect of animal manure is attributed to enhancement physical criteria of the soil including better aeration, better water holding capacity, better nutrient availability and good balance between nutrients in the soil solution and improvement of nutrient exchange between of the soil (Zebarth et al., 1999). Slow release of nutrients from cow manure during growth period and hence low leaching of the nutrients could also be other criteria for animal manures, which improved flower induction and flower size (stigma length), which related to stigma weight and the yield index. Both vegetative and reproductive (flowering) growth of saffron are highly dependent on plant nitrogen status, especially in the second year, when plants are nutrient exhausted, and generally yield begin to fall due to nitrogen deficiency and overcrowding of corms. The consistently high yield of spice obtained from an established crop has probably been assisted by the annual application of balanced fertilizers to maintain adequate soil nutrient levels (Sampathu et al., 1984). With correct nutrient management, saffron plant can produces well for at least 4 years.

Conclusion

Sufficient animal manure application can supplied N requirement of saffron and it can improve soil physical and chemical features especially, nutrient retention, in the poor and infertile soils. In part, this may be associated with release of nitrogen in the applied organic material which can improve saffron soil nutrient availability and soil biological activity. Cow manure can also buffer against moisture stress resulting from inadequate irrigation. Cow manures may be ineffective at sites which have multi-nutrient fertigation regimes or frequent irrigation which leaches N excessively from the root zone.

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REFERENCES

Abdullaev FI (2002). Cancer chemopreventive and tumoroicidal properties of saffron (*Crocus sativus* L.). Exp biol. Med., 227: 20–25.

Anderson DL, Henderson LJ (1986). Sealed chamber digestion for plant nutrition analysis. Agron. J., 78: 937-938.

Behdani M, Koocheki A, Nassiri M, Rezvani-Moghaddam P (2005). Evaluation of quantity relations between yield and nutrient consumption in saffron: On farm study. J. Iran Field Crop Res., 3(1): 32-38.

Behzad S, Razavi M, Mahajeri M (1992). The effect of mineral nutrients (N. P. K.) on saffron production. Acta Hort., 306: 426-430.

Benschop M (1993). *Crocus*. In: The physiology of flower bulbs. Hertogh, A. de; Nard, M. le ed. Amsterdam, Elsevier, pp. 257-272.

Deo B (2003). Growing saffron-The world's most expensive spice. Crop and Food Research (New Zealand Instit. Crop Food Res., No. 20.

Dhar AK, Sapru R, Rekha K (1988). Studies on saffron in Kashmir. 1. Variation in natural population and its cytological behavior. Crop Improv., 15(1): 48-52.

Fernández JA (2004). Biology, biotechnology and biomedicine of saffron. Recent Res. Dev. Plant Sci., 2: 127-159

Koocheki A, Nassiri M, Behdani MA (2006). Agronomic Attributes of Saffron Yield at Agroecosystems. Acta Hort., 739: 24-33.

McGimpsey JA, Douglas MH, Wallace AR (1997). Evaluation of saffron (*Crocus sativus* L.) production in New Zealand. New Zealand J. Crop Hortic. Sci., 25: 159-168.

Mollafilabi A (2003). Experimental findings of production and ecophysiological aspects of saffron (*Crocus sativus*). Acta Hort., 650: 195-200.

Nair SC, Pannikar B, Pannikar KR (1991). Anti tumor activity of Saffron (*Crocus sativus* L.). Can. Lett., 57: 109-114.

Negbi M, Dagan B, Dror A, Basker D (1989). Growth, flowering, vegetative reproduction and dormancy in the saffron crocus *(Crocus sativus* L.). Israel J. Bot., 38: 95-113.

Rezaian S, Forouhar M (2002). The effect of N fertilizers (Urea, S.C.U) with manure on the saffron yield. Acta Hort., 650: 201-205.

Rios JL, Giner RM, Manez S (1996). An update review of saffron and its active constituents. Phytother. Res., 10: 189-193.

Sampathu SR, Shivashankar S, Lewis YS (1984). Saffron (*Crocus sativus* L.) cultivation, processing, chemistry and standardization. C.R.C. Crit. Rev. Food Sci. Nutr., 20: 123-157.

Winterhalter P, Straubinger M (2000). Saffron. Renewed interest in an ancient spice. Food Rev. Int., 165: 39-59.

Zebarth BJ, Neilsen GH, Hogue E, Neilsen D (1999). Influence of organic waste amendments on selected soil physical and chemical properties. Can. J. Soil Sci., 79: 501-504.