Introduction

Saffron (*Crocus sativus* L.) is the most expensive spice widely used for its aroma and analgesic in traditional medicinal preparations (Abdullaev, 2002). This crop has a very low harvested yield. Yield can be increased by improving plant nutritional stature (McGimpsey et al., 1997; Deo, 2003; Fernández, 2004). Application of chemical fertilizers in infertile soil increased both yield (up to 15 kg ha^{-1}) (Sampathu et al. 1984). 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). Maintaining the balance between vegetative and reproductive growth (more flowers) is, however, one of the most important aim in saffron fertilizer management. Increase vegetative vigor must be associated with number and length stigma of flower. Therefore, the hypothesis was "a combination of chemical and organic fertilizers can be leaded to higher yield".

Materials and Methods

The project was carried out in a Randomized Complete Block Design experiment with four replications under environmental conditions of Zanjan, Iran during two years (2004 to 2005). The treatments were: control (neither chemical, nor organic fertilizer); N only; P only; organic fertilizer (20 t ha^{-1} cow deep litter manure = M_n); N+M_n; P+M_n; N+P; and N+P+M_n. 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}. Cow deep litter manure (mixture of bedding straw + manure) at rate of 20 t ha^{-1} was applied once a year in the early spring. One cubic meter of decayed sawdust, as original bedding material, weighed 120 kg, with 180% water holding capacity.

Uniform saffron corms were planted in furrows. Stigmas were immediately separated from flowers. Flower fresh weight (g), flower number (No. m^{-2}), stigma length (mm), stigma fresh weight (g $flower^{-1}$), and stigma dry weight (g m^{-2}) were measured. Leaf area index and the rate of corm multiplication (new corms yr^{-1}) were calculated. Plant samples were oven dried at 60°C for 48 hours and ground to pass through a 40 mesh screen, and were analysed for mineral status. All soil and plant samples were used for mineral analysis of samples.

Results and Discussion

The highest average of saffron flower fresh weight (0.99 g), with the longest stigma (30 mm) were obtained in the combination of chemical and organic fertilizers (N+P+M_n) treatment during experiment (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 N+P+M_n treatment, whereas, the lowest average of yield (0.23 g m^{-2}) was recorded for control (Table 1). Application of cow manure (20 t ha^{-1}) improved soil fertility. While, N only application increased LAI, but no significant on yield. The highest average of LAI (2.8), and the lowest (1.3) were observed in the N-only, and control treatments, respectively (Table 2). The greatest average of corm multiplications rate (5.7 new corms yr^{-1}), and the lowest (2.5 new corms yr^{-1}) were obtained in the N+P+M_n and control treatments, respectively (Table 2). The largest (11.5 g) corms were obtained in the M_n treatment (Table 2). The highest amount of corm yield (No. corms m^{-2} >5 g) was 109 m^{-2}, which it was recorded in the N+M_n treatment (Table 2). Yield (stigma dry weight) has a stronger correlation (R= 0.743) with stigma length, compared to correlation (R = 0.570) of yield with flower fresh weigh. Leaf mineral concentrations (%DW) increased by cow manure (20 t ha^{-1}), N, and P applications, but there was no significant (P = 0.05) difference in some mineral leaf concentrations (Table 3). Leaf petiole mineral nutrient concentrations (% DW) were quite adequate for all elements (Table 3).

Soil fertility management for saffron production can be mainly based on combination of organic fertiliser with chemical (N, P). Some farmers keep only their domestic animals (cow, sheep, and cattle) in their fields. This mainly improves soil fertility, but it may can not supply all of nutrient requirements for optimum yield. Combination of animal manure (20 t ha^{-1} cow manure) with P (40 kg ha^{-1}) and N (50 kg ha^{-1}) was resulted to the highest yield (Table 1). It can be said that 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). Chemical combined with cow manure could be well utilized by the plants because of more nutrient availability in the soil, especially whear water is limmited in the summer. Increasing yield is due to the role of available phosphorous on the growth of flower parts. In the mean while, nitrogen can improves vegetative and reproductive growth. Nitrogen uptake was high in the first year, and markedly increased in the second year. As a consequence, N increases flowering in the second year. Furthermore, this condition leaded to excellent longer period flowering. Comparison to non fertilizer conditions (control) that results in less and shorter period flowering with small stigmas. Nitrogenous fertilizer also allows a greater leaf area index (LAI), and crop growth rate (CGR). Consequently influence a significant effect on the production of daughter corms (Table 2). Slow release of nutrients from cow manure during growth period and hence low leaching of the nutrients could also be other feature for cow manure (Zebarth et al., 1999). It must be remembered that there are less Fe and Zn available in soils with low OM and high alkaline and high pH, and sustaining the level of these nutrients could be problematic.

References

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Table 1. Effect of nutrient on means of flower fresh weight, stigma length, fresh and dry weights of stigmas of saffron in the zone of Zanjan, Iran.

Treatment	flower FW (g)	stigma length (mm)	stigmas FW (g/flw)	stigmas DW (g m^{-2})
control	0.50	19	0.022	0.24
N	0.70	22	0.028	0.28
P	0.70	20	0.029	0.28
M_n	0.80	23	0.038	0.29
N+P	0.90	25	0.039	0.29
N+M_n	0.90	26	0.040	0.28
P+M_n	0.80	24	0.039	0.31
N+P+M_n	0.99	30	0.052	0.45
LSD	0.19	3.2	0.011	0.03

Table 2. Effect of nutrient on leaf area index, rate of multiplication corm, and means of corm weight of saffron (*Crocus sativus* L.) in the zone of Zanjan, Iran.

Treatment	LAI	corm multiplication rate (new corm yr^{-1})	corm fresh weight (g)	No. corm (m^{-2})
control	1.7	2.5	6.8	95
N	2.8	4.2	7.5	107
P	2.1	3.3	8.6	93
M_n	2.9	4.5	11.5	96
N+P	2.4	3.0	10.4	92
N+M_n	2.5	4.5	9.2	109
P+M_n	2.1	4.0	9.6	101
N+P+M_n	2.6	5.7	8.1	108
LSD	0.75	1.4	1.8	8.5

Table 3. Mean mineral concentration of saffron blade leaf (after harvesting of flowers) in the zone of Zanjan, Iran.

Treatment	N (%)	P (%)	K (%)	Mg (%)	Ca (%)	B ppm	Cu ppm	Fe ppm	Mn ppm	Zn ppm
control	0.64	0.54	3.09	0.37	1.98	33	28	68	189	48
N	0.87	0.55	3.60	0.46	1.84	52	12	94	195	43
P	0.63	0.85	3.82	0.39	1.95	38	14	82	153	44
M_n	0.70	0.60	4.04	0.57	1.51	36	13	90	195	41
N+P	0.75	0.56	3.95	0.49	1.61	37	11	95	190	42
N+M_n	0.88	0.62	3.85	0.33	1.78	48	12	75	161	36
P+M_n	0.76	0.69	3.93	0.47	1.40	37	24	70	172	40
N+P+M_n	0.86	0.61	3.58	0.35	1.72	36	32	76	163	52
LSD	0.16	0.25	0.75	0.17	0.48	11	9.5	15	19	8.7