Morphological Aspects of Saffron with Respect to Industrialization

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ABSTRACT

Saffron (Crocus sativus L) is major economic cash crop of Kashmir valley. In this study different sites were studied on comparative basis. Different physico chemical and morphological parameters were studied which indicates appreciable variation with respect to different sites. The study indicates decrease in quality of crop with respect to industrialization.

Keywords: Pollution, Saffron, morphology

I. INTRODUCTION

Saffron (*Crocus sativus*) is a bulbous perennial plant of iris family (Iridaceae) treasured for its golden-colored, pungent stigmas, which are dried and used to add flavor and color in foods (Plessner *et al*. 1989). The active components in saffron have many therapeutic applications in many traditional medicines as antiseptic, antidepressant, anti-oxidant, digestive, anti-convulsant and good source of minerals (Mohammadi, 1997). It is also rich in many vital vitamins and has numerous useful properties. Saffron (Crocus *sativus* L) is major economic cash crop of Kashmir valley (Kamili *et al* 2007). Almost all saffron grows in a belt bounded by the Mediterranean in the west and the rugged region encompassing Iran and Kashmir in the east. In 2005, the second-ranked Greece produced 5.7 t (5,700.0 kg), while Morocco and Kashmir, tied for third rank, each produced 2.3 t (2,300.0 kg) Ghorbani (2008). Kashmir valley was once known to produce one of the finest qualities of saffron as the environment was most suitable for growth and propagation of plant. The average yield of saffron in Kashmir has been showing a gradual decline from the last few years which are of major concern. Decline in production among other factors may be attributed to decrease in fertility of the soils, both in respect of macro and micro-nutrients. But now the greatest threat to the quality and quantity of this very plant are cement factories (Jan and Bhat, 2006; Rafiq *et al.*, 2008; Jan, 2009) as most of them are located in proximity to saffron fields in valley.

1.1 Study sites

Jammu and Kashmir is a state in northern India. It is located mostly in the Himalayan mountains, and shares a border with the states of Himachal Pradesh and Punjab to the south. Jammu and Kashmir consists of three divisions: Jammu, Kashmir Valley and Ladakh, and is further divided into 22 districts. The study area was in the Pulwama district of Kashmir with five study sites, these are listed in table 1.

Table 1: Characteristic feature of various sites

Sites Selected	Characteristic Features		
	Geographical co-ordinates	**Altitude**	**Location**
Site I	34°02′ 08.61″N latitude and 075°01′02.2″E longitude	1650masl (5413.3 feet)	0 km away from the cement factory
Site II	34°02′37.7″N latitude and 074°57′31.0″E longitude	1648 masl (5406.8 feet)	3 km away from the cement factory
Site III	34°01′53.8″N latitude and 074°57′32.5″E longitude	1645 masl (5396.9feet)	5 km away from the cement factory
Site IV	34°02′15.0″N latitude and 074°55′30.0″E longitude	1645 masl (5396.6feet)	7 km away from the cement factory
Site V	34° 01'81.61''N latitude and 074° 57' 33.2''E longitude	1642 masl (5387.1feet)	12 km away from the cement factory

II. METHODOLOGY

For the purpose of accomplishing the problem selected for the current research program, standard methodology was used after appropriate and careful surveying of literature.

III. RESULTS

3.1 Physico chemical parameters

3.1.1 Dust deposition on different parts of saffron plant

During the 24 months of consecutive study dust deposition on saffron plant was estimated during the vegetative and flowering phases which indicated the maximum dust deposition near factory site (site I) while there was zero cement dust found at control sites (site II –V) during the years 2013-2014 (Fig.1).

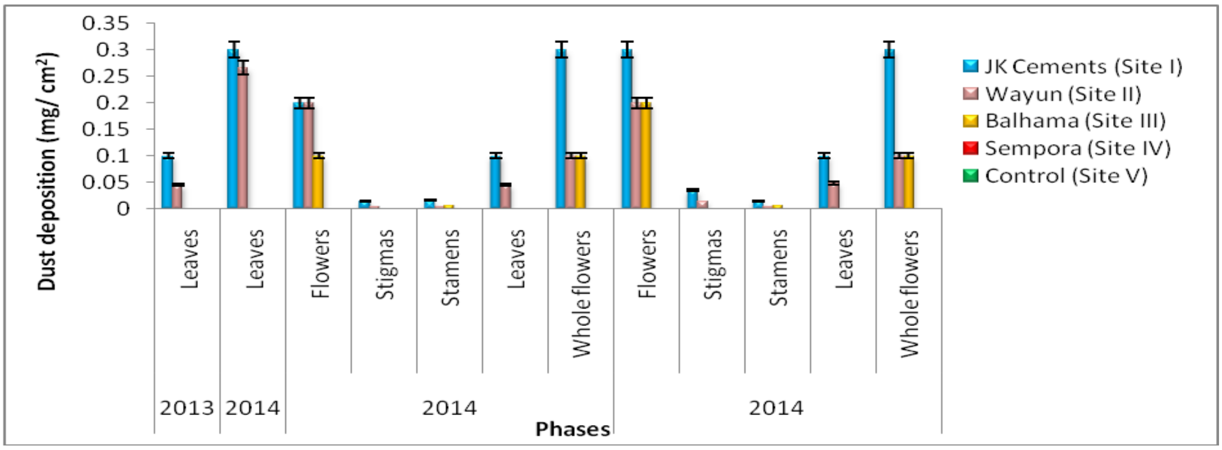

Fig.1: Variations in dust deposition (mg/cm^2) on different parts of saffron during different developmental stages at different sites for two consecutive years. Values are represented as Mean and SEM (n=5).

3.1.2 pH of leaf extract

The leaf extract pH recorded during vegetative phase varies from 6.04 - 7.02 in the year 2013 from site I to site V. While during the year 2014, it varies between 6.09 - 6.9 from site I to site V. Similarly during flowering phase of 2013 the leaf pH varied from 6.2 at site I to 7.01 at site V while during the year 2014, it varied from 6.27 to 7.1 while moving from site I to site V (Table 2).It was observed that, the leaves found at sites nearest to factory were acidic compared to control site.

Table 2: Variation in pH of leaf extract at different sites

Sites	Variation in pH of leaf extract			
	Vegetative phase		Flowering phase	
	2013	2014	2013	2014
I	^{a}6.044±0.02	^{a}6.09±0.05	^{a}6.21±0.11	^{a}6.27±0.07
II	^{a}6.83±0.08	^{a}6.56±0.3	^{a}6.6±0.4	^{a}6.6±0.3
III	^{a}6.84±0.02	^{a}6.52±0.3	^{a}6.7±0.11	^{a}6.7±0.1
IV	^{a}6.93±0.03	^{a}6.61±0.37	^{a}6.89±0.06	^{a}6.4±0.2
V	^{ab}7.02±0.01	^{a}6.9±0.44	^{ab}7.01±0.01	^{ab}7.1±0.13

Values are represented as mean±SD (n=5), Data was analyzed by ANOVA using Duncan's multiple range test (SPSS-17.0); the values with different superscript along the columns are statistically significant at $p<0.05$.

3.1.3 pH of leaf wash

Leaf wash pH recordings during vegetative phase vary from 8.48 - 7.12 in the year 2013 from site I to site V. While during the year 2014, it varies between 8.24 – 7.13 from site I to site V. Similarly during flowering phase of 2013 the leaf wash pH varied from 8.4 at site I to 7.37 at site V while during the year 2014, it varied from 8.2 to 7.13 while moving from site I to site V (Table 3). It was observed that, the leaves wash found at sites nearest to factory were alkaline when compared to control site.

Table 3: Variation in pH of leaf wash at different sites

Site	Variation in pH of leaf wash			
	Vegetative phase		Flowering phase	
	2013	2014	2013	2014
I	^{ab}8.48±0.1	^{ab}8.24±0.1	^{ab}8.4±0.1	^{ab}8.2±0.1
II	^{a}7.17±0.07	^{a}7.15±0.04	^{a}7.14±0.03	^{a}7.6±0.2
III	^{a}7.2±0.1	^{a}7.2±0.2	^{a}7.18±0.07	^{a}7.18±0.07
IV	^{a}7.17±0.11	^{a}7.21±0.09	^{a}7.22±0.09	^{a}7.28±0.05
V	^{a}7.12±0.06	^{a}7.13±0.1	^{a}7.37±0.4	^{a}7.13±0.05

Values are represented as mean±SD (n=5), Data was analyzed by ANOVA using Duncan's multiple range test (SPSS-17.0); the values with different superscript along the columns are statistically significant at $p<0.05$.

3.2 Morphological Parameters

3.2.1 Length of saffron flower (flower, stamen and stigma)

From the data it was observed that the length of flowers sprouting at the site nearest to the factory (site I) was within an average value of 4.5 for both the years i.e. 2013 and 2014 which was lowest among five study sites and maximum value was found at site V i.e. 6.98 and 6.96 during 2013 and 2014 respectively.

Similarly the length of stamen nearest to the factory was with an average value of 2 and 2.04 during 2013 and 2014 respectively and highest value of 2.44 and 2.46 was found at site V for 2013 and 2014 respectively (Table 4).

The average length of stigma nearest to the factory site was with an average value of 2.1 during both the years of 2013 and 2014 while as average maximum value of 3.04 and 3.16 was observed during 2013 and 2014 at site V respectively (Table 4).

As we move from cement factory i.e. from site I to site V, there was a gradual increase in the length of flowers, stamens and stigmas but no such increase or decrease was seen at particular site for particular part of plant during two years of study i.e. from 2013 to 2014

Table 4: Length of flower, stamen and stigma (cm) at different sites

Sites	Length of flower, stamen and stigma (cm)					
	Length of flower (cm)		Length of stamen (cm)		Length of stigma(cm)	
	2013	2014	2013	2014	2013	2014
I	^{a}4.5±0.05	^{a}4.5±0.2	^{a}2±0.04	^{a}2.04±0.05	^{a}2.12±0.1	^{a}2.1±0.15
II	^{a}4.9±0.04	^{a}4.95±0.05	^{a}2.06±0.05	^{a}2.04±0.05	^{b}2.42±0.08	^{a}2.32±0.08
III	^{a}4.98±0.04	^{a}4.99±0.004	^{a}2.1±0.1	^{a}2.12±0.08	^{b}2.46±0.05	^{a}2.4±0
IV	^{ba}5.48±0.04	^{ab}5.48±0.04	^{ab}2.4±0.08	^{a}2.4±0.07	^{d}3.24±0.04	^{b}3.08±0.08
V	^{c}6.98±0.4	^{c}6.96±0.05	^{ab}2.44±0.05	^{a}2.46±0.05	^{cd}3.04±0.05	^{b}3.16±0.11

Values are represented as mean±SD (n=5), Data was analyzed by ANOVA using Duncan's multiple range test (SPSS17.0); the values with different superscript along the columns are statistically significant at $p<0.05$.

3.2.2 Fresh and dry weight of corms (g/25cm2)

The observations with regard to average fresh and dry biomass (g/25cm^2) of the live corms of *Crocus sativus* L. at the five comparative sites were as under:

Average fresh biomass of corms growing at the factory site (site I) was 209g/25cm^2 and 291g/25cm^2 at site V for the year 2013.While as for the year 2014 average fresh biomass of the corms was 208g/25cm^2 at site I and 300g/25cm^2 at site V during vegetative phases. During dormant phases the fresh weight of corms varied from 208g/25cm^2 in 2013 and 207g/25cm^2 in 2014 at site I while highest values were found at site V with average value of 286g/25cm^2 and 293g/25cm^2 during 2013 and 2014 respectively. In flowering phase of 2013 it was 208g/25cm^2 and in 2014 it was 207g/25cm^2 at site I while it was 265g/25cm^2 and 285g/25cm^2 during 2013 and 2014 respectively at site V. It has been observed that there is gradual increase in fresh weight of corms while moving from cement polluted area (site I) towards that of control area (Site V).It has also been observed that there is decrease in fresh weight of corms at site I during 2014 when compared with 2013 observations. Average dry biomass of the corms during vegetative phase of 2013 was in the range of 203g/25cm^2 at site I and 282g/25cm^2 at site V while during 2014 it was 205g/25cm^2 at site I and 288g/25cm^2 at site V. From the observation of dormant phases it shows variation from 201g/25cm^2 in 2013 and 201g/25cm^2 in 2014 at site I while a highest average value of 275g/25cm^2 and 286g/25cm^2 was observed at site V with during 2013 and 2014 respectively. In flowering phase of 2013 and 2014 the dry biomass of corms varies from 202g/25cm^2 and 202±0.9g/25cm^2 respectively at site I while as it was 259g/25cm^2 and 278g/25cm^2 for 2013 and 2014 respectively at site V (Table 5). Thus from observations it is concluded that there is gradual decrease in the dry biomass while moving from control site (site V) towards that of cement polluted site (site I) during all the three developmental phases of the saffron plant

3.2.3 Fresh and dry weight of saffron plant (flowers, stigma and stamen)

From the data collected it has been observed that the fresh and dry weight of five saffron flowers (5) were found to be responding in the following manner with average minimum value of 1.45g at site I and maximum of 2g was found at site V while as the dry weight varied from 1.26g at site I and 1.84g at site V during the year 2013. Similarly during the year 2014, the average fresh and dry weight of stigmas varied from 1.478g and 1.26g at site I while as at site V it varies from 2g and 1.56g respectively (Fig.2).

From the data collected, it is observed that fresh weight of stigmas varied from 0.1185g at site I and 0.1996g at site V while as dry weight varied from 0.11178g at site I and 0.18952g at site V during the year 2013. Similarly during 2014 the average fresh and dry weight of stigmas varies from 0.1168g and 0.11192g at site I. At site V it varied from 0.19978g and 0.19298g respectively.

Average fresh and dry weight of the five saffron stamens(5) were found to be responding in the following manner with average minimum value of 0.16682g at site I and average maximum of 0.1758g was found at site V. While dry weight varied from 0.158575g at site I and 0.16935g at site V during 2013. Similarly during 2014 the average fresh and dry weight of stigmas varies from 0.16578g and 0.15988g at site I while at site V it varied from 0.16868g and 0.15586g respectively. As we move from the cement factory site (site I) towards control site (site II to V) there is gradual increase in fresh and dry biomass of the flowers, stamens and stigmas (Fig.2).

Table 5: Estimation of fresh and dry weight of corms during different developmental stages of saffron

Sites	Fresh and dry weight determination of corms											
	Weight (g/quadrant)											
	Vegetative phase				Dormant phase				Flowering phase			
	2013		2014		2013		2014		2013		2014	
	Fresh Wt.	Dry Wt.	Fresh Wt.	Dry Wt.	Fresh Wt.	Dry Wt.	Fresh Wt.	Dry Wt.	Fresh Wt.	Dry Wt.	Fresh Wt.	Dry Wt.
I	^{a}209±0.1	^{a}203±1	^{a}208±0.6	^{a}205±1	^{a}208±0.7	^{a}201±3	^{a}207±0.2	^{a}201±1	^{a}208±0.1	^{a}202±0.8	^{a}207±0.1	^{a}202±0.9
II	^{b}250±1	^{b}239±6	^{b}252±1	^{b}239±2	^{b}255±5	^{b}244±5	^{a}260±5	^{b}250±5	^{b}228±1	^{b}219±1	^{b}239±1	^{b}229±1
III	^{b}258±2	^{bc}245±6	^{b}260±2	^{c}250±2	^{bc}268±7	^{c}259±6	^{a}270±3	^{bc}261±4	^{c}255±2	^{c}246±2	^{c}249±1	^{c}242±3
IV	^{bc}274±2	^{d}262±2	^{bc}274±2	^{cd}266±4	^{d}280±9	^{cd}269±6	^{a}280±0.4	^{d}271±4	^{cd}267±4	^{cd}259±5	^{d}262±1	^{cd}254±2
V	^{c}291±1	^{e}282±4	^{d}300±9	^{e}288±8	^{d}286±3	^{d}275±3	^{a}293±2.3	^{e}286±2	^{c}265±2	^{cd}259±5	^{e}285±0.6	^{e}278±1

values are represented as mean±SD (n=5), Data was analyzed by ANOVA using Duncan's multiple range test (SPSS17.0); the values with different superscript along the columns are statistically significant at $p<0.05$.

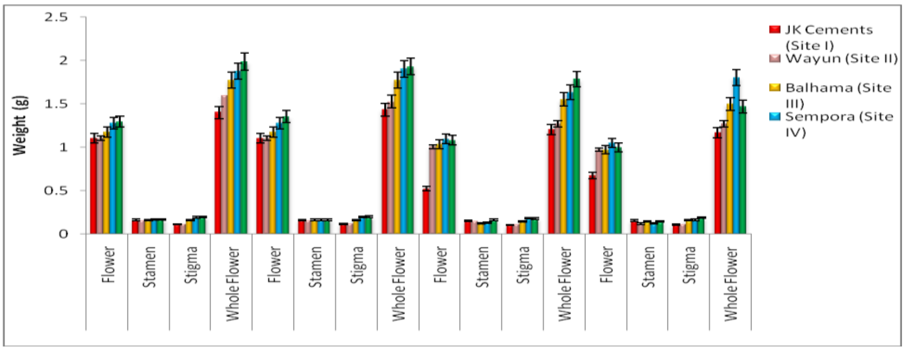

Fig.2: Variations in dry weight and fresh weight (g) of different parts flower of saffron during various developmental stages at different sites. Values are represents as Mean and SEM (n=5)

3.2.4 Number of plants/quadrat

Five quadrats of 25cm^2 were laid at sites and average values were found to be responding in the following manner.

It was recorded that at site I (nearest to cement factory) the average number of plants/ quadrat were low (6.6 and 5.4) in the year 2013 and 2014 respectively, however, the higher number of plants (15.8 and 12) were recorded at control site (site V) for the year 2013 and 2014 respectively during vegetative phases.

During flowering phases, same trend was observed with the maximum number of plants (17.8 and 14.4) at site I and minimum (7.8 and 6.8) number of plants at site V for year 2013 and 2014 respectively (Table 6).

As we move from cement factory i.e. from site I to site V, there was a gradual increase in the number of plants at other sites while moving away from the cement pollution source during all the developmental phases of the saffron plant.

3.2.5 Number of corms/bunch

From the data collected, it was observed that at site I (nearest to cement factory) the average number of corms were low (4.8 and 3.4) in the year 2013 and 2014 respectively, however, the higher number of corms (14.2 and 12.2) were recorded at control site (site V) for the year 2013 and 2014 respectively during vegetative phases.

During flowering phases, same trend was observed with the maximum number of corms (14.8 and 13.6) at site I and minimum (5 and 3.8) number of corms at site V for year 2013 and 2014 respectively (Table 7).

As we move from cement factory i.e. from site I to site V, there was a gradual increase in the number of corms at other sites while moving away from the cement pollution source during all the developmental phases of the saffron plant.

Table 6: Number of plants/quadrat at different sites

Site	Number of plants/quadrat					
	Vegetative phase		Dormant phase		Flowering phase	
	2013	2014	2013	2014	2013	2014
I	^{a}6.6±1	^{a}5.4±1.1	^{a}7.8±0.8	^{a}6.8±1.3	^{a}7.8±1	^{a}6.6±0.5
II	^{b}11.8±0.8	^{a}6.2±0.8	^{b}11±1	^{b}10.2±0.8	^{b}11±1	^{a}7.8±0.8
III	^{b}13.6±1.1	^{b}9.2±1.4	^{b}11.6±0.5	^{bc}12.4±1	^{bc}12.8±1.3	^{ab}9.4±0.5
IV	^{c}15.8±0.8	^{b}9±1	^{bc}13.8±1.3	^{c}13.6±0.8	^{c}14±0.3	^{c}13.8±0.8
V	^{c}15.4±1	^{c}12±2.5	^{d}17.8±0.8	^{c}14.4±0.5	^{c}14.8±0.8	^{d}16.8±1.4

Values are represented as mean±SD (n=5), Data was analyzed by ANOVA using Duncan's multiple range test (SPSS17.0); the values with different superscript along the columns are statistically significant at $p<0.05$.

Table 7: Number of corms/ bunch at different sites

Sites	Number of corms/bunch at different sites			
	Vegetative phase		Flowering phase	
	2013	2014	2013	2014
I	^{a}4.8±0.8	^{a}3.4±0.5	^{a}5±0.7	^{a}3.8± 0.8
II	^{b}6.6±1	^{b}7±2	^{b}7±0.7	^{b}5.6±1
III	^{c}11.6±1	^{bc}8.2±3	^{c}11.2±0.8	^{c}11.4±1
IV	^{c}11.8±1	^{c}10.4±2	^{c}11.8±1	^{c}11.8±1
V	^{d}14.2±1	^{c}12.2±3	^{d}14.8±1	^{cd}13.6±1

Values are represented as mean±SD (n=5), Data was analyzed by ANOVA using Duncan's multiple range test (SPSS17.0); the values with different superscript along the columns are statistically significant at $p<0.05$.

IV. DISCUSSION

Analysis of the present investigation shows that, dust fall was highest on plant parts (leaf, flower, stigma, and stamen) near cement factory site (Uysal *et al.*, 2011; Rahman and Ibrahim, 2012). Dust deposition induces changes in the biochemical parameters by increasing and decreasing their level in the plant leaves (Rai and Panda, 2014).

pH of leaf extract and leaf wash are important parameters and are used as indicators of air pollution in the industrial areas. Plant samples collected from polluted site exhibited leaf extract pH mean values towards acidic side, which may be due to the presence of SO_2 and NO_x in the ambient air causing a change in pH of the leaf sap towards acidic side (Swami *et al.*, 2004).

pH of leaf wash was estimated to be exhibiting a declining trend as one moved away from the cement factory i.e. site I > site II > site III > site IV > site V. The strongly alkaline nature of pH values of leaf wash could be attributed to either formation of hydroxides of calcium (Santosh and Tripathi, 2008; Jan, 2009) or due to the dust from limestone materials which factory uses for the manufacturing of cement and the dust which arises during quarrying and transportation of the raw materials. The results are also consistent with Nilson (1995) who observed that in the nearest surroundings of the cement plant, the stems of trees were covered with a cement crust and recorded a striking increase in the pH of the pine bark.

Saffron is a growing perennial plant, regenerating from the vegetative multiplication of its underground corms. A corm produces upto five flowers. Both fresh and dry biomass (g/25cm^2) of saffron corms from the various locations suffering from the cement dust pollution of varied intensity indicated that biomass was higher at sites suffering from lesser intensities of cement dust deposition and was thus directly related to the degree of intensity of cement dust deposition (Jan, 2009; Lone 2010). Ghani, (2010) indicated the reduction in total biomass due to metal pollutants in different plant components. Same increasing trend was observed in saffron flowers while moving from cement factory site to control site (site I< site II< site III<site IV<site V). Biomass (Fresh and dry) was found to be significantly and negatively correlated with soil pH (Jan, 2009). Site wise consecutive decline in photosynthetic pigment contents could probably be related to the decline in biomass of flowers. From the results it was observed that length of flowers, stigma and stamen was carried out. During two consecutive years of study, the length was minimum at cement factory site while as it increased while moving away from source of pollution towards control site which was also reported by Jan, (2009) and Lone, (2010).

With regard to the impact of varied intensities of cement dust pollution on the number of corms/25cm^2, the number of corms was higher at the site free of cement pollution and gradually declining towards source site vis-a-vis plants the reason might be due to less food accumulation in the corms due to decrease in leaf size, losses in chlorophyll content and subsequently lesser production of daughter corms (Jan, 2009). Similarly, less production of seeds due to cement dust pollution have been reported in *Brassica campestris* (Shukla *et al*., 1990) and *Brassica oleraceae* (Zargar *et al*., 1999).

V. CONCLUSION

The cement factories are the major contributors of pollution particularly in form of cement dust that consists of toxic substances. The impacts of deposition of cement dust or release of toxic gases from cement factories in the area on saffron production is supported by current research findings

VI. ACKNOWLEDGEMENTS

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