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EFFECT OF CEMENT DUST ON THE FOLIAR GROWTH, FLORAL MORPHOLOGY, CROCIN CONTENT AND YIELD OF SAFFRON(*CROCUS SATIVUS* L.)

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Corms of saffron were sown in selected plots in Sep.2002 and were treated with cement dust at the rate of 1 and 2 g m^{-2}/day for a period of 7 months (Sep.-March) for two consecutive growth years. The treated plants showed a consistent reduction in the photosynthetic pigments,phytomass as well as length of leaves .The results also showed that except biomass of the stigma,pistil and whole flower, no significant variation was observed in floral morphological characteristics after one year of growth . However, in the second year significantly ($p<0.01$) greater reduction was observed in the size of perianth, length and biomass of the pistil and stigma (saffron of commerce) and the whole flower. The yield of saffron (kg ha^{-1}) also suffered a greater loss in the second year (ranging 12.92-19.66 %) compared to the first year (ranging 10.71-16.66 %), and the losses were related to the amount of dust treatment. Crocin content of the stigma did not exhibit any change due to cement dust pollution.

Key words: Cement dust, saffron, chlorophyll, crocin content.

Cement producing factories release an enormous amount of cement dust in to the atmosphere causing a variety of damage to plants.Cement dust after escaping in to the atmosphere settles on the soil and plant surface and due to its hygroscopic nature forms a hard crust on the surface .Reduction in the photosynthetic pigments , biomass , growth and yield of plants due to the cement dust pollution has been reported by many workers (Czaja, 1961; Lerman, 1972; Shukla *et al.*, 1990;Mandre, *et al.*, 1992, Pandey *et al.*, 1996 Mandre & Tuulmets, 1997; Mandre and Korsjukov, 2000; Ots,2000., Cesar & Lepedus 2001, Deepali & Khan, 2002). The present investigation was undertaken to study the effect of different concentrations of cement dust on the growth performance and yield of saffron (*Crocus sativus* Linn.). Saffron is an important cash crop of Kashmir and in the valley it is mainly grown in the karewas of Pampore (district Pulwama) where five cement factories are operational in the areas adjoining saffron fields . These factories release an enormous amount of cement dust in the atmosphere and according to an unpublished report, the dust fall measured at a distance of 1 and 2 Km from the Khrew cement factory (district Pulwama) has been found to be 2.08 and 1.19 g m^2/day respectively.

MATERIALS AND METHODS

. Mature corms of saffron were sown 20 cm apart in rows spaced 25 cm in 1.5 x 3 m^{-2} plots in September, 2002 in the selected plots ($T_1$and T_2) at Konibal saffron sub station of SKUAST-K near Pampore in Randomized Block Design. Three plots were maintained for each treatment and for the control. Cement dust was obtained from Khrew cement factory (JK Cements) which contains Lime stone = 78%, Clay=22.5%, Gypsum =5% and Iron ore =1.5%.The cement dust was sprayed on the selected plots T_1 and T_2 in the morning hours by using cardboard chambers (size 1.5 x 1 m^{-2}) at the rate of 1 and 2 g m^{-2}/ day (5-6 days /week)for a period of seven months for two consecutive growth years (Sep.2002 –March 2003 and Sep. 2003- March 2004). It may be mentioned that in Kashmir valley, saffron corms are sown in Aug. – Sept. and flowering takes place in Oct. – Nov. of the same season. The flowering also occurs before the emergence of leaves and its foliage remains green till April.

Fifty foliar samples from each replicating plot were randomly collected at 30, 90 and 150 day intervals from the onset of vegetative growth for two

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consecutive growth years and analyzed for various parameters viz., length, biomass and chlorophyll pigment content. The biomass of the foliage was determined after drying them at 80 °C for 24 h. Chlorophyll pigments were estimated by following the method of Hiscox & Israelstam (1979) after gently cleaning the leaves with moist cotton. For studying various froristic parameters viz. length of flowers, size of perianth and pistil, about 100 flowers were randomly picked from each replicating plots during the first as well as in the second years flower harvest. The dry weight of the flowers was estimated after drying them for a few days in solar driers.

For soil analysis the samples were randomly collected at the end of the first and second year of growth from all the replicating plots (depth 20 cm) and analysed for various parameters .The pH and electrical conductivity were determined by the method given in Piper (1966). Available N, P and K were estimated by Micro – Kjaldahl's method (Jackson,1973) and exchangeable Ca and Mg were estimated by Atomic Absorption Spectophotometer (GEC,902 Australia). The crocin content of stigma (saffron of commerce) was determined at Regional Research Laboratory, Canal Road, Jammu. The mean values of the different parameters obtained for the control and polluted samples were compared using the *t*- test.

RESULTS AND DISCUSSION

Cement dust covering the vegetative organs of the plants forms a crust when it becomes moist due to dew, fog or light rain . This phenomenon creates changes in the light, temperature and water regimes of the plant tissues (Borka,1980) . In the present study the most significant differences could be observed in chl-a ,while chl-b was less affected (Table- 1).

During the first year of growth the highest reduction of ca. 47% and 67% was recorded in the chlorophyll –a content of the foliage of 150 day old plants of the T_1 and T_2 plots respectively compared to the other ages. Chlorophyll-b also recorded severe losses due to dust pollution (ca. 22% in T_1 and ca. 44% in T_2) and the loss was maximum in the young foliage (30 days). In the second year the reduction in the photosynthetic pigments followed similiar trends but the losses were slightly more compared to the first year . Several authors in the past have also recorded losses in the content of chlorophyll pigments due to cement dust pollution (Shukla *et al.*, 1990; Mandre *et al.* 1992., Misra *et al.*, 1993, Mandre & Tuulmets ,1997; Cesar & Lepedus,2001). This decrease in the chlorophyll pigments might have been caused by the highly alkaline nature of cement dust which might have degraded the chlorophyll molecules and /or by shading (Pajenkamp, 1961; Borka, 1980). Lerman (1972) suggested that continuous application of cement clogs the stomata thus interfering with the gaseous exchange. This may lead to increased leaf temperatures which may retard chlorophyll synthesis (Mark, 1963; Singh & Rao, 1981).Mandre & Tuulmets (1997) have also opined that decrease in light availability caused due to dust pollution may lead to decreased elemental uptake and hold the view that the inhibition of the absorption of the active parts of the solar radiation spectrum participating in photosynthetic process might have directly contributed to the low concentration of chlorophyll in Norway spruce needles under the influence of the high level of dust pollution.The data also indicated the decrease in chl a/ b ratio . The sensivity of chl-a /chl-b ratio to dust has been also observed in Norway spruce by Mandre & Tuulmets (1997) who have attributed it to the effect of several mediate external and internal factors. In addition to chlorophylls, carotenoids have also been regarded as potential bioindicators of air pollution. This study has also shown that the carotenoid content was significantly less in the treated samples and the losses were recorded lesser in the young foliage than in the old foliage. Further, T_2 plots experienced higher losses compared to T_1 plots. These reductions may be attributed to the adverse impacts on the biosynthetic processes under the influence of alkaline dust.

The length of the foliage of the plants is determined by genetic constitution and also by the edaphic and weather conditions, especially temperature and water regimes, but it also depends upon the dust load , the duration of its effect and the

Table 1. Effect of cement dust treatment on the photosynthetic pigments of saffron leaves.

Parameters	Treat-ment	Age of foliage in days					
		30		90		150	
		Ist year	II year	Ist year	II year	Ist year	II year
Chlorophyll-a (mg/ g fresh weight)	T_1	0.30 (40.00)*	0.29 (41.00)*	0.35 (44.44)*	0.34 (46.09)*	0.37 (47.17)*	0.36 (48.59)*
	T_2	0.18 (64.00)*	0.17 (66.00)*	0.22 (65.07)*	0.21 (67.18)*	0.23 (67.14)*	0.22 (68.30)*
	C	0.50	0.50	0.63	0.64	0.70	0.71
Chlorophyll – b (mg/g/fresh wt.)	T_1	0.07 (22.22)*	0.07 (26.31)*	0.12 (20.00)*	0.12 (21.87)*	0.17 (19.04)*	0.17 (20.45)*
	T_2	0.05 (44.44)*	0.05 (47.36)*	0.10 (33.37)*	0.09 (36.66)*	0.16 (23.80)*	0.16 (25.00)*
	C	0.09	0.09	0.15	0.16	0.21	0.22
Total chlorophyll (mg/g fresh wt.)	T_1	0.37 (37.28)*	0.36 (38.65)*	0.47 (39.74)*	0.47 (40.50)*	0.54 (40.65)*	0.54 (41.93)*
	T_2	0.23 (61.01)*	0.22 (63.02)*	0.32 (58.97)*	0.30 (61.39)*	0.39 (57.14)*	0.38 (58.06)*
	C	0.59	0.59	0.78	0.79	0.91	0.93
Chl a/ chl b ratio	T_1	4.28 (22.88)*	4.21 (19.96)*	2.91 (30.71)*	2.76 (35.21)*	2.17 (34.83)*	2.08 (35.40)*
	T_2	3.60 (35.13)*	3.40 (35.36)*	2.20 (47.61)*	2.21 (48.12)*	1.35 (59.45)*	1.36 (57.76)*
	C	5.55	5.26	4.20	4.26	3.33	3.22
Carotenoids	T_1	0.05 (37.50)*	0.05 (41.17)*	0.08 (38.46)*	0.08 (41.42)*	0.11 (42.10)*	0.10 (47.36)*
	T_2	0.04 (50.00)*	0.03 (54.11)*	0.06 (53.84)*	0.06 (55.00)*	0.08 (57.89)*	0.79 (58.42)*
	C	0.08	0.08	0.13	0.14	0.19	0.19

Values are means of 6 replicates
T_1= Plots treated with cement dust at the rate of 1 g m^{-2} day^{-1}
T_2= Plots treated with cement dust at the rate of 2 g m^{-2} day^{-1}
C = Control
Figures in parentheses represent percentage reduction over control
* Significant at $p<0.01$ level.

tolerance of the plants .Cement dust may cause essential negative changes and inhibit the growth of plants , reduce the dimension of their leaves and decrease their biomass. (Shukla et al .,1990; Mandre & Ots,1999) . The phytomass and length of the foliage of the saffron treated with the cement dust was significantly lower than those of the control plants and the per cent decrease was recorded more in 150 days old foliage as well as in the T_1 plots experiencing more dust load. Further the losses were recorded more in the second year of growth compared to the first year (Table 2). Such reductions may be due to reduced photosynthesis, through a combination of factors such as reduced interference with the gaseous exchange of foliage due to clogging of stomata, interception in the incident light due to cement encrustation on the leaf surface, pigment degradation and intra or inter-cellular changes in the leaves (Shukla *et al.*, 1990).

It is also clear from the data (Table 3) that except the biomass of the stigma, pistil and flower no significant variation was observed in various floral

Table 2. Effect of cement dust treatment on the length and biomass of saffron foliage.

Parameter	Growth year	Treament	Plant age in days		
			30	90	150
Length of leaves(cm)	I	T_1	6.8 (2.85)**	13.15 (8.99)*	16.12 (12.15)*
		T_2	6.50(7.14)*	13.10(9.40)	15.00(16.00)
		C	7.00	14.46	18.35
	II	T_1	6.77(3.22)**	13.59 (9.15)*	16.07 (15.75)*
		T_2	6.48 (7.42)*	13.00 (13.10)*	15.56 (18.14)*
		C	7.00	14.96	19.01
Fresh weight of leaves (mg)	I	T_1	63.00(10.00)	98.00(3.57)	140.00 (15.15)
		T_2	59.00(15.71)	94.00(16.27)*	120.00(37.5)
		C	70.00	112.00	165.00
	II	T_1	63.8(16.00)*	95.00(17.39)	132.00(21.89)
		T_2	66.00(18.00)*	93.00(19.13)	104.00(38.46)*
		C	76.00	115.00	169.00
Dry weight of leaves (mg)	I	T_1	16.00(11.11)*	21.50(17.30)	28.00(24.32)
		T_2	15.50(13.88)*	22.00(15.38)*	29.00(21.16)
		C	18.00	26.00	37.00
	II	T_1	16.00(6.08)*	23.00(14.81)	29.00(21.62)
		T_2	15.00(19.18)*	21.50(20.00)*	26.00(29.72)*
		C	18.56	27.00	37.50

Values are means of 50 replicates
T_1= Plots treated with cement dust at the rate of 1 g m^{-2} day^{-1}
T_2= Plots treated with cement dust at the rate of 2 g m^{-2} day^{-1}
C = Control
Figures in parentheses represent percentage reduction over control
*,** Significant at $p<0.01$ and $p<0.05$ level respectively .

Table 3. Effect of cement dust on various floral characteristics, crocin content and the yield of saffron.

S. No.	Parameters	First year			Second year		
		T_1	T_2	C	T_1	T_2	C
1.	Length of whole flower (cm)	7.81 (0.00)	7.75 (0.76)^{NS}	7.81	7.97 (10.75)*	6.92 (11.39)*	7.81
2.	Length of perianth (cm)	4.13 (0.48)^{NS}	4.10 (1.20)^{NS}	4.15	3.95 (4.81)*	3.13 (24.57)*	4.15
3.	Width of perianth (cm)	1.78 (0.0)	1.78 (0.00)	1.78	1.61 (9.55)*	1.28 (28.00)*	1.78
4.	Length of stigma (mm)	31.60 (0.0)	31.60 0.00)	31.60 (0.0)	27.48 (13.03)*	23.48 (25.69)*	31.60
5.	Length of style (mm)	39.82 (0.0)	39.82 (0.00)	39.82 (0.0)	34.30 (13.86)*	29.88 (24.96)*	39.82
6.	Total length of pistil (stigma and style) (mm)	71.42 (0.0)	71.42 (0.00)	71.42	61.78 (13.49)*	53.36 (25.28)*	71.42
7.	Fresh weight of whole flower (g) (10 flower basis)	4.98 (4.14)*	4.18 (19.76)*	5.21	4.18 (19.76)*	3.74 (28.21)*	5.21
8.	Dry weight of whole flower (g) (10 flower basis)	0.87 (3.48)*	0.86 (6.97)*	0.87	0.77 (13.95)*	0.72 (24.41)*	0.87
9.	Fresh weight of stigma (g) 10 flower basis	0.33 (2.94)**	0.32 (5.88)*	0.34	0.30 (11.76)*	0.25 (26.47)*	0.34
10.	Dry weight of stigma (g) 10 flower basis	0.085 (2.29)**	0.086 (1.14)**	0.087	0.077 (11.49)*	0.072 (17.24)*	0.087
11.	Fresh weight of pistil (g) 10 flower basis	0.47 (2.08)**	0.45 (6.25)*	0.48	0.39 (18.75)*	0.31 (35.41)*	0.48
12.	Dry weight of pistil (g) 10 flower basis	0.096 (3.03)*	0.091 (8.08)*	0.099	0.091 (8.08)*	0.087 (12.12)*	0.099
13	Crocin content of stigma (%)	9.79 (0.0)	9.79 (0.0)	9.79	9.64 (1.53)^{NS}	9.50 (2.96)^{NS}	9.79
14.	Yield of saffron (kg ha^{-1})	1.50 (10.71)*	1.40 (16.66)*	1.68	1.55 (12.92)*	1.43 (19.66)*	1.77

Values are means of 100 replicates (for S.No.1-12) and 3 replicates (for S.No.13 & 14)
Figures in parentheses represent percentage reduction over control
T_1= Plots treated with cement dust at the rate of 1 g m^{-2} day^{-1}
T_2= Plots treated with cement dust at the rate of 2 g m^{-2} day^{-1}
C = Control .; *,** Significant at $p<0.01$ and $p<0.05$ level respectively.

characteristics of the saffron plants (T_1 and T_2) harvested in the first year. However, in the second year losses were significantly higher in all parameters The commercial part of the flower i.e., stigma suffered a significant ($p< 0.01$) loss of 13.03 , 25.69; 11.76 and 26.47; 11.49 and 17.24 % in its length, fresh weight and dry weight in the T_1 and T_2 plots respectively. Reductions were also observed in fresh and dry weight of the flowers and the losses were more in the T_2 plants that were exposed to higher dust pollution compared to the T_1 plots. Cement dust also significantly ($p<0.01$) reduced the yield of saffron (kg ha^{-1}) in both the years, and the per cent loss was higher in the second year's harvest (ranging from 12.9 to 19.7 %), than first year harvest (ranging from 10.7 -16.7 %) in T_1 and T_2 plots respectively. On the other hand crocin content of the stigma did not show any significant variation in the flower harvest of both the seasons. The reduction in the values of various parameters viz., length, biomass and its yield in the second year might be due to the less food accumulated in the corms (due to the losses in chlorophyll content) and subsequently, lesser production of daughter cormels. It might have affected the growth and development of floral primordia as the corms experienced particulate pollution stress for a longer period compared to corms planted in the Ist year. Less production of flowers, pods and seeds due to cement dust pollution has also been reported by Shukla *et al.* (1990) and Zargar *et al.* (1999) in *Brassica campestris* and *Brassica oleracea*, respectively.

The values for soil pH, conductivity as well as exchangeable Ca and Mg in the case of the treated plots was higher compared to the control (Table 4) . The increase in soil pH in the polluted soil might have been caused by the hydroxides of Ca and Al formed during hydration (Stratman &Vant Haut, 1956; Pajenkamp, 1961; Czaja, 1966) which may impair the various metabolic processes in the plants indirectly. Also changes in soil pH due to cement dust in the polluted plots might have affected the growth of the foliage (Schonbeck, 1960; Scheffer *et al.*, 1961;

Table 4: Soil characteristics of the experimental plots at the end of first and second year of growth.

No	Parameter	First year			Second Year		
		T_1	T_2	C	T_1	T_2	C
1.	pH	8.05 (1.38)**	8.25 (3.90)*	7.94	8.10 (2.01)**	8.36 (5.28)*	7.94
2.	Ec (d Sm^{-1})	0.17 (13.33)*	0.21 (40.00)*	0.15	0.19 (26.66)*	0.25 (66.66)*	0.15
3.	Exch. Ca Cmol (P^+) Kg^{-1}	16.00 (6.66)*	18.00 (20.00)*	15.00	20.00 (33.27)*	26.00 (73.33)*	15.00
4.	Exch.Mg C mol (P^+) Kg^{-1}	1.70 (13.33)*	1.80 (20.00)*	1.50	1.75 (16.66)*	1.90 (26.66)*	1.50
5.	Available N Kg ha^{-1}	319.80 (27.15)*	287.00 (34.52)*	439.04	313.60 (28.57)*	282.24 (35.69)*	439.04
6.	Available P Kg ha^{-1}	14.65 (21.15)*	10.90 (41.33)*	18.58	14.52 (21.85)*	10.80 (41.87)*	18.58
7.	Available K Kg ha^{-1}	266.00 (10.13)*	260.00 (12.16)*	296.00	264.00 (10.81)*	261.00 (11.82)*	296.00

Values are means of 3 replicates
T_1= Plots treated with cement dust at the rate of 1 g m^{-2} day^{-1}
T_2= Plots treated with cement dust at the rate of 2 g m^{-2} day^{-1}
C = Control
Figures in parentheses represent percentage reduction over control
* and ** Significant at p<0.01 and p<0.05 level respectively.

Czaja, 1962) as has also been observed in the present study. On the other hand, exchangeable NPK was reduced. In general the alkalization of soil might complicate the mineral nutrition process of the plants and unbalance the mineral composition of the foliage (Mendre *et al.*, 1992) and subsequently, may be responsible for the decrease of pigment concentration and might affect the various biochemical processes in the plants .

Thus the present study shows that cement dust adversely affects the growth and yield of saffron. Further, the losses are more in the second year's harvest as well as in the plots that had been exposed to higher amount of dust . The properties of the soil also changed to an undesirable extent due to cement dust pollution.

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