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Full Length Research Paper

Comparative analysis of growing media impact on saffron flowering and corm formation

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The objective of this research was to determine the effects of different growing media on saffron growth and corm formation in greenhouse conditions. In the experiment four different treatments were used. These were (1) soil+sand (control), (2) soil+sand+manure, (3) soil+sand+manure applied as a double layer above and bottom of corm bed, and (4) soil+sand+manure+ nitfojips-K. The results revealed that effects of the growing media on most of the characters were significant. Cow manure mixtures especially with double layers had a positive effect on the flower and stigma weight. Average flower weight per plant change between 0.157 - 0.240 g. The corm size did not change significantly in treatments 1, 2 and 3. However, in treatment 4, both corm weight and corm size were significantly lower than they were in the other treatments. The results suggested that the growing medium was one of the important factors for saffron flower and corm formation.

Key words: Saffron, stigma, yield, corm.

INTRODUCTION

Saffron (*Crocus sativus* L.) is the world's most expensive crop among aromatic and medicinal plants as it is difficult to produce in higher quantaties. It is sold between 200 and 1600 USD/kg in the world markets depending on quality (Garcia, 1997). Major saffron producer countries are Greece, Spain, Morocco, Iran and India. Italy, Swit-zerland, Argentina, Turkey, Azaerbaijan and Austuralia are the others to contribute remarkable amounts to the total world saffron production, which is about 205 tonnes annualy (Fernandez, 2004).

Saffron has been used since the ancient times for different purposes such as medicinal, aromatic, food ingredient, textile dyeing, etc. Dried stigmata of saffron were used to give flavor to some meals. The plant pro-duces several secondary metabolites such as safranal, crocin, and crococetin (Negbi et al., 1989).

Saffron is a sterile triploid and does not set viable seeds. Thus, it is propagated vegetatively by its corms. Saffron is generally collected from flora especially in several developing countries, which puts a serious pressure on the existence of this endemic species. Thus, cultivation of saffron, instead of collecting from wild, in those areas would reduce this pressure. There have been some breeding studies in order to develop new varities. However, sterility of saffron limits the success through convential plant breeding. Therefore, studies to increase yield and quality have focused on different culti-vation methods (planting, fertilization, irrigation, growing media, etc.) (Behnia et al., 1999; Unal and Cavusoglu, 2005). An ealier study showed that nitrogen application contributes to fresh flower yield of saffron (Unal and Cavusoglu, 2005). Behzad et al. (1992a) stated that organic matter and cow manure applications elevated fertility of soils in saffron cultivation. When cow manure is applied before planting, it also has a contribution to improvement of moisture holding capacity and structure of soil under non-irrigated conditions (Munshi et al., 1989).

Some of the earlier studies on saffron argued that chemical fertilization alone did not much improve flower yield, unless applied together with organic material such as cow manure (Behzad et al., 1992b; Behnia et al., 1999; Unal and Çavu o lu, 2005). Similarly, McGimpsey et al. (1997) reported that application of sawdust mulch increased stigma yield. These findings suggested that natural materials improving soil structure might have more effect on saffron yield than chemical fertilization.

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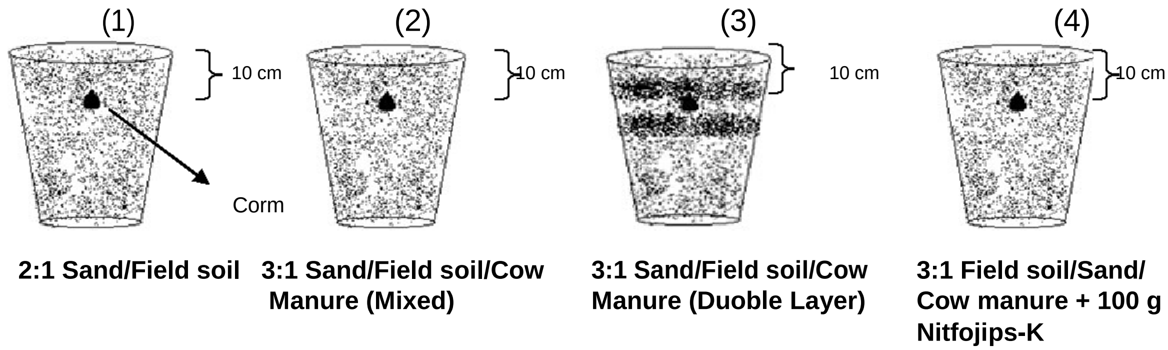

Figure 1. Materials and their proportions used to fill in pots.

Table 1. Components of growing media.

Media (Treatment)	pH	EC (mS/cm)	Lime (%)	Organic matter (%)	Phosphorous (kg/da)	Potassium (kg/da)
Control	7.75	0.64	12.10	0.89	28	78
SSM	6.77	2.35	7.25	5.41	104	279
SSM-K	5.59	7.02	8.86	5.01	118	369

SSM: Soil + sand + manure, SSM-K: Soil + sand + manure + nitfojips-K.

Consequently, it can be inferred that growing media should play a major role in saffron production.

The objective of this research was to determine the effects of different growing media on saffron growth and corm formation in greenhouse conditions.

MATERIALS AND METHODS

The corms used in this research were obtained from the Agricultural Directorate of Safranbolu, Turkey. The corms with 30 mm diameter were sown 10 cm deep into the pots containing different growing media. Effects of applications were determined by measuring different plant traits, namely emergence and flowering dates, plant height, flower weight, stigma weight, stigma height, shoot number, number of corms, corm size, and corm weight per plant. After all the measurements were taken on the daughter corms, they were classified into three different groups (<10 mm, 10 - 15 mm, >15 mm) by their size. Irrıgation was made manually as needed.

Growing media and GDD calculations

Four types of growth media were used in this research. These were (1) soil+sand (control), (2) soil+sand+manure, (3) soil+sand+manure applied as a double layer above and bottom of corm bed, and (4) soil+sand+manure+ nitfojips-K (100 g/pot). Commercial organic fertilizer nitfojips-K contains 20% total organic matter, 25% SO_3, 15% CaO, 5% P_2O_5, 15% N. Proportions of the materials used in the pots (25 x 20 cm) are given in Figure 1. Twelve pots were used for every application and two corms were planted in each pot. Soil samples were taken from each growing medium and analysed for determination of soil components. The results were presented in Table 1.

Greenhouse moisture and temperature were measured daily with basic Hubu apharatus (Brothers Co., Sweden). These data were used for calculating growing degree days (GDD) values, using the formula (Mcmaster and Willem, 1997):

$$GDD = (T_{max}+T_{min})/2 - T_{base}.$$

where,

T_{base}: base temperature (10^{o}C).
T_{max}: the highest temperature recorded in a given day
T_{min}: the lowest temperature recorded in a given day

Figure 2 shows temperature and relative humidity values in the greenhouse from planting to the end of flowering. Mcmaster and Willem (1997) pointed out that GDD values based on the soil temperature did not significantly differ from values calculated using the air temperatures. Thus, in our study, air temperature was used for GDD calculation.

Statistical analysis

This reseach was arranged in a completely randomized block desing with three replicates. PROC GLM procedure of SAS was used for variance analysis (SAS Inst., 1999). Mean seperations were carried out with Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Results of variance analysis revealed that effects of the growing media on most of the characters were significant (Tables 2 and 3). Treatment 4, containing nitfojips-K (Commercial organic fertilizer) produced significantly shorter plants than the other treatments (Table 2). Although number of shoots per plant was the highest in treatment 4, the lowest stigma weight and height, conse-

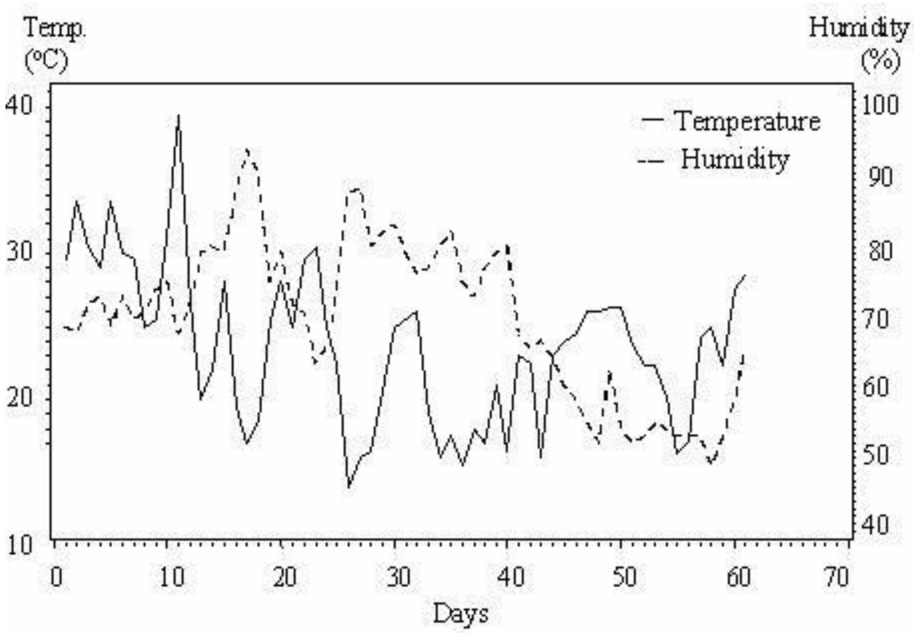

Figure 2. Temperature and relative humidity values in greenhouse during growth period of saffron.

Table 2. Results of data analyses for shoot and flower related characters in saffron.

Growing media	Plant Height (cm)	Number of shoots	Flower weight (g)	Stigma Weight (g)	Stigma Height (cm)	Germin. date	Flowering date	GDD for germ.	GDD for Flow.
1-Fs	28.0 a[1]	6.08 ab	0.200 ab	0.019 c	2.93 a	40.1 b	42.4 b	405.2 b	421.0 b
2-M+S+Fs	32.3 a	4.72 b	0.215 a	0.022 b	2.59 b	42.5 b	49.4 ab	431.9 b	495.6 ab
3-M+S+Fs (DL)	29.9 a	7.17 a	0.240 a	0.024 a	2.67 b	39.5 b	43.2 b	399.0 b	426.8 b
4-M+S+Fs+N	8.6 b	7.42 a	0.157 b	0.010 d	1.86 c	59.6 a	52.0 a	598.4 a	520.1 a
Mean Squares									
Rep. (df = 2)	11.64	0.025	0.0020	0.000002	0.222	29.46	8.967	1944.4	86.18
Treatment (df = 3)	354.12***	4.533 *	0.0034*	0.000005*	0.631***	272.43**	62.912*	26656.7 **	7058.42 *
Error (df = 6)	5.23	0.730	0.0004	0.000002	0.011	24.79	12.474	1916.1	1188.56

Fs: Field soil, **M**: Cow manure, **S**: Sand, **N**: Nitfojips-K, **GDD**: Growing Degree Days.
[1]: Means with the same letter are not different at 0.05 significance level.
*, ** and ***: significant at 0.05, 0.01 and 0.001 level, respectively.

quently the lowest flower weight was produced in treatment 4. The highest flower and stigma weights were obtained by treatment 3. Treatment 1 produced longer but thinner stigmata. This indicates that cow manure mixtures especially with double layers had a positive effect on the flower and stigma weight.

Seedbed conditions, including soil structure, texture, temperature, moisture, oxygen, and microrganisms, have important roles on emergence and seedling growth (Wuebker et al., 2001). In our study, treatment 4 containing nitfojips-K caused a delay in corm emergence and flowering compared to the other treatmets (Table 2). Interestingly, in the pots containing nitfojips-K, flowering occured before shoot formation. This case was described by Mathew (1977) and Plessner et al. (1989) as “subhysterenahous behaviour” and “hysteranthy”, respectively. This could be an advantage for machine-harvesting of flowers without leaves (Souret and Weathers, 1999).

Benschop (1993) stated that temperature was the most important enviromental factor controlling growth and flowering of *Crocus* species by affecting enzyme activity in plant metabolism (Keyhani et al., 2002). One way of measuring the temperature requirements for each growth stage of plants is determining growing degree days (GDD) (Stewart et al., 1998). Our results showed that the treatment 4 compared to the other treatments produced significantly higher mean GDD values for both shoot

Table 3. Results of data analyses for corm related characters in saffron.

Growing media	<10 mm			10 – 15 mm			>15 mm			Average		
	Number of corms	Corm weight (g)	Corm size (mm)	Number of corms	Corm weight (g)	Corm size (mm)	Number of corms	Corm weight (g)	Corm size (mm)	Number of corms	Corm weight (g)	Corm size (mm)
1-Fs	2.67 b[1]	0.42 a	8.31	2.08	1.12 a	12.35	2.22 a	2.63 a	17.16	6.97 b	1.36 a	12.35 ab
2-M+S+Fs	2.19 b	0.37 ab	8.31	1.75	1.01 ab	12.37	2.16 a	2.59 a	17.99	6.11 b	1.40 a	13.58 a
3-M+S+Fs (DL)	4.06 b	0.42 a	8.07	2.33	1.11 a	12.24	1.92 a	2.85 a	18.66	8.30 a	1.35 a	11.49 b
4-M+S+Fs+N	6.17 a	0.27 b	8.11	1.83	0.87 b	12.22	1.00 b	1.25 b	15.29	8.33 a	0.48 b	9.53 c
Mean Squares												
Rep. (df = 2)	0.43	0.007	0.19	0.062	0.005	0.264	0.009	0.022	0.456	1.35*	0.04	0.86
Treatment (df = 3)	9.53 **	0.015 *	0.05	0.208	0.041*	0.016	0.341**	0.496*	2.408	3.54 **	0.60 *	8.68 **
Error (df = 6)	0.93	0.003	0.16	0.145	0.010	0.468	0.016	0.075	1.558	0.49	0.10	0.81

Fs: Field soil, **M**: Cow manure, **S**: Sand, **N**: Nitfojips-K, **GDD**: Growing Degree Days.
[1]: Means with the same letter are not different at 0.05 significance level.
*, ** and ***: significant at 0.05, 0.01 and 0.001 level, respectively.

emergence and flowering. Knowing the GDD requirement for a genotype would be helpful for the production with the lowest energy cost and time consumption in a controlled greenhouse.

Corm formation of saffron is one of the important characters because corm is the only source for propagation. Although the plants in treatment 3 and 4 produced similar total number of corms, the average corm weight and size in treatment 3 were higher than treatment 4. In saffron cultivation, the quality of corms (i.e., size and emergence capacity) is of importance, as well as the number of corms produced. Earlier studies revealed that mature and bigger corms gave more flowers and doughter corms (Molina et al., 2005; Omidbaigi, 2005; Vurdu et al., 2002). Therefore, one of the objectives in production of saffron is to obtain bigger corms. In Table 3, the corms were grouped based on their diameters as <10 mm, 10 – 15 mm and >15 mm. The corm size did not changed significantly in treatment 1, 2 and 3. But, in treatment 4, both corm weight and size were significantly lower than the other treatments.

When the number of corms per plant and their sizes are considered, the best growing medium was found to be the treatment 3. The same treatment also resulted in higher values for flower and stigma characters. This may be due to the fact that double layer manure application supplies a good surrounding for rooting and easy emergence. These results are supported by previous findings (Unal and Cavusoglu, 2005; Behnia et al., 1999). In these studies, it was pointed out that saffron flower and corm yield were elevated by organic matter and nitrojen application.

In conclusion, growing media or soil texture/structure significantly affected flower and corm yield in saffron. The best medium in this experiment was soil+sand+manure mixture with double layers application of manure above and bottom of corm bed. It would be necessary to confirm these results in field conditions before applied into practice.

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