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Production of organic Saffron (*Crocus sativus*) using biofertilizer and vermicompost

SABIA LATIF[1], M Y ZARGAR[1], F A NEHVI[2], MISBAH AJAZ[1]* and MALIK SAJAD AHMAD[1]

Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu and Kashmir 190 025, India

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Saffron (*Crocus sativus* L.) is a commercial crop that has been farmed in Kashmir since ancient times. It is a very important high value and low volume condiment (Stephens 2003). Its most valuable commercial component is its thread-like crimson stigma, which is used mostly in the food, beverage, cosmetics, medical, and textile industries. The three remarkable quality characteristics of saffron are aroma (safranal), flavour (picrocrocin) and colouring pigment (crocin) which have made it staple in the world market and contributed to its dominance in generating foreign exchange for the nation. Additionally, it has made a strong mark on contemporary pharmacology by successfully treating a wide range of illnesses, including serious conditions like cancer. Saffron farming is currently limited to the Jammu and Kashmir districts of Pulwama, Budgam, Srinagar and Doda. In the state of Jammu and Kashmir, 5707 acres were planted to this crop in the 1996–1997 growing season, yielding 15.95 million tonnes (mt) annually. With an annual yield of 6.86 mt and a productivity of 2.23 kg/ha, the area shrank to 3143 ha in 2004–05 (Nehvi *et al*. 2008). Except for a few instances of nitrogen application in Kashmir, nutrient management procedures have not been followed, leading to poor saffron soils. Many customers are worried about the health effects of synthetic pesticides, food additives, preservatives and food colouring agents at the moment. Particularly given the inclusion of inorganic materials, the potential health concerns are intolerable. The advantages of organic farming systems in terms of ecology, the environment and food safety, coupled with the rising consumer demand for organic food in many nations, demonstrate that it can be a suitable substitute for conventional farming methods (Poudel *et al.* 2002).

An experiment was conducted at Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during 2018–19 within Saffron Research Station in Pampore and at Dry Land Agricultural Research Station in Budgam. The experiment was laid out in Randomized Complete Block Design (RCBD) with 12 treatments, viz. T_1, recommended dose of NPK; T_2, *Pseudomonas* @11.5 g + 115 g sand; T_3, *Pseudomonas* @11.5 g + 115 g sand + recommended dose of vermicompost of kitchen waste; T_4, *Pseudomonas* @11.5 g + 115 g sand + recommended dose of vermicompost of FYM; T_5, *Azotobacter* @11.5 g + 115 g sand; T_6, *Azotobacter* @11.5 g + 115 g sand + recommended dose of vermicompost of kitchen waste; T_7, *Azotobacter* @11.5 g + 115 g sand + recommended dose of vermicompost of FYM; T_8, *Azospirillium* @11.5 g + 115 g sand; T_9, *Azospirillum* @11.5 g + 115 g sand + recommended dose of vermicompost of kitchen waste; T_{10}, *Azospirillum* @11.5 g + 115 g sand + recommended dose of vermicompost of FYM; T_{11}, recommended dose of vermicompost of kitchen waste; T_{12}, recommended dose of vermicompost of FYM; one control (T_0, no fertilizer and no vermicompost) and 3 replications of each treatment on 2×2.3 m^2. Except when it rained, flowers were picked every 1–2 days. After any wetness had dried, the whole, completely opened blooms were picked by hand, close to the ground. The stigmas were then manually detached from the flowers and air-dried at 30°C for 24 h. Pale portions of the design were not collected, giving the item an even, glossy, dark-red colour. The total numbers of flowers taken as well as the weights in both fresh and dry form of the stigmas obtained were noted. The number of blooms, weight, and size of the corms, cormlets, and mother corm were used to evaluate the impact of organic inputs. Data were subjected to the statistical analysis as per standard statistical procedures as followed by (Gomez K A and Gomez A A 1984) by using Statistical-AG Software Licensed to FOA, Wadura SKUAST-Kashmir. Control and treatment plots were laid in the same field following recommended agronomic practices of SKUAST-K with resembling soil types and properties in order to avoid bias due to differential soil nutrient status.

The analysis of the data (Table 1) showed that there were substantial differences in the number of flowers/plot

[1]Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu and Kashmir; [2]Saffron Research Station , Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu and Kashmir. *Corresponding author email: misbamalik98@gmail.com

Table 1 Effect of vermicompost and biofertilizers on the floral and corm attributes of saffron at Dryland Agriculture Research Station (DARS), SKUAST-Kashmir and Saffron Research Station (SRS), Pampore

Code	No. of flowers	Flower weight (g)	Pistil weight (g)	No. of daughter/ mother corm	Total no. of corms/plot	Corm weight (kg)
T_0 (DARS)	55.00±3.21	15.10±1.73	0.46±0.01	1.16±0.05	266±6.35	1.74±0.05
T_0 (SRS)	52.00±3.21	14.30±1.03	0.44±0.01	1.10±0.05	253±8.08	1.65±0.05
T_1	107.00±4.61	30.70±1.79	0.89±0.01	1.76±0.05	404±6.35	2.79±0.05
T_1	115.00±2.88	33.20±1.59	0.96±0.02	1.90±0.05	437±7.50	2.58±0.03
T_2	109.00±4.04	30.80±1.79	0.90±0.02	1.77±0.05	407±7.50	2.73±0.05
T_2	117.00±4.04	33.00±1.62	0.97±0.01	1.90±0.05	437±6.92	3.00±0.05
T_3	125.00±4.61	35.70±1.15	1.04±0.02	2.10±0.05	478±7.50	3.59±0.08
T_3	127.33±3.52	36.70±1.73	1.07±0.02	2.20±0.05	506±6.92	3.45±0.05
T_4	126.00±4.04	36.00±2.30	1.06±0.02	2.08±0.05	483±7.50	3.36±0.03
T_4	127.00±3.64	36.70±1.73	1.07±0.02	2.20±0.05	506±6.35	3.62±0.05
T_5	115.00±4.04	33.10±1.15	0.95±0.02	1.94±0.05	446±7.50	3.15±0.57
T_5	120.00±4.61	34.60±1.21	1.00±0.01	1.90±0.05	437±7.50	3.10±0.05
T_6	138.00±4.61	39.80±2.94	1.15±0.01	2.79±0.05	641±8.66	3.85±0.05
T_6	135.00±3.51	38.40±2.54	1.14±0.02	2.80±0.05	644±7.50	4.00±0.05
T_7	139.00±4.04	40.10±1.21	1.17±0.01	2.01±0.05	660±8.66	4.87±0.57
T_7	137.00±5.77	39.50±2.30	1.16±0.01	2.90±0.05	667±6.92	4.45±0.04
T_8	116.00±4.04	32.60±1.73	0.97±0.01	2.01±0.05	462±7.50	2.88±0.06
T_8	120.00±4.61	34.10±1.44	1.00±0.01	2.00±0.05	460±8.66	3.23±0.05
T_9	130.00±5.19	36.90±2.30	1.09±0.02	2.88±0.05	662±6.92	5.20±0.57
T_9	130.00±4.61	37.50±2.36	1.11±0.02	2.90±0.05	667±6.92	5.35±0.05
T_{10}	136.00±3.46	39.20±2.19	1.15±0.01	3.06±0.05	703±6.36	5.30±0.57
T_{10}	132.00±4.04	37.70±2.19	1.11±0.02	3.10±0.05	713±6.92	5.59±0.05
T_{11}	118.00±3.46	34.10±2.25	0.99±0.01	2.04±0.05	469±7.50	3.19±0.05
T_{11}	122.00±4.04	34.60±1.21	1.03±0.01	2.00±0.05	460±6.92	3.29±0.05
T_{12}	123.00±4.61	35.10±1.18	1.03±0.02	2.06±0.05	473±8.08	3.35±0.05
T_{12}	125.00±2.88	35.70±1.73	1.05±0.01	2.10±0.05	483±6.92	3.44±0.04
CD (P=0.05) (DARS)	12.66	5.48	0.06	0.16	21.96	0.91
CD (P=0.05) (SRS)	11.72	5.37	0.06	0.17	22.18	0.16

Refer to methodology for treatment details.

for all treatment combinations. The use of biofertilizers and vermicompost encouraged more blossoms, which directly influenced the yield of saffron at both locations at the SKUAST-Kashmir Dry Land Agriculture Research Station (DARS). Application of T_7 treatment recorded highest number of flowers/plot (139), fresh flower weight (g) (40.10), pistil weight (g) (1.17) followed by T_6 (138),(39.80), (1.15); T_{10} (136), (39.20),(1.15); T_9 (130), (36.90),(1.09) ; T_4 (126), (36.00), (1.06); and T_0 (55.00), (15.10), (0.46) respectively. Similar trend of best combination for this trial was also observed at Saffron Research Station (SRS), Pampore T_7 (137), (39.50), (1.16); followed by T_6 (135), (38.40), (1.14); T_{10} (132), (37.70), (1.11); T_9 (130), (37.50), (1.11); T_4 (127), (36.70), (1.07); T_3 (127), (36.70), (1.07); T_{12} (125), (35.70),(1.05) and T_0 (52.00), (14.30), (0.44). Data averaged over locations recorded highest number of flowers/ plot (136.50), flower weight/plot (39.35 g) and pistil weight/ plot (1.15 g) in T_7 (Table 2). Best combination on an average recorded an increase of 135% in flower number, 167% in flower weight, and 155% in pistil weight over control. Vermicompost and biofertilizer application significantly changed the examined flower features. The generation of auxins by microbial inoculants (*Azotobacter*), which led to an increase in cell division and cell elongation, may be the cause of the noticeable rise in these floral characteristics (Preethi *et al*. 1999, Padmadevi *et al.* 2004). According to a survey, a plant's need for nutrients generally determines its vegetative and reproductive growth (Amiri 2008). The number of corms/mother corm, total number of corms/ plot and corm weight/plot (kg) in trials laid at DARS

Table 2 Effect of vermicompost and biofertilizers on the floral and corm attributes of saffron over control (average of two locations)

Code	No. of flowers	Flower weight (g)	Pistil weight (g)	No. of daughter/ mother corm	Total no. of corms/plot	Corm weight (kg)
T_0	53.50	14.70	0.450	1.13	259.50	1.695
T_1	111.00	31.85	0.925	1.83	420.50	2.655
T_2	117.50	35.30	0.935	1.83	422.00	2.895
T_3	127.50	35.40	1.045	2.15	487.00	3.485
T_4	132.50	36.40	1.070	2.84	494.00	3.522
T_5	120.50	33.35	1.010	2.88	449.00	2.990
T_6	134.00	38.65	1.120	2.84	654.00	3.925
T_7	136.50	39.35	1.155	2.88	663.50	4.660
T_8	122.00	34.40	0.975	2.03	464.00	3.220
T_9	133.50	38.40	1.115	2.93	673.83	5.325
T_{10}	133.16	37.65	1.12	2.99	687.50	5.395
T_{11}	124.00	35.15	1.02	2.04	466.50	3.295
T_{12}	122.50	35.30	1.03	2.12	469.00	3.315
CD (P=0.05) Location	N.S	N.S	0.016	N.S	5.93	N.S
Treatment	8.22	3.77	0.048	0.117	15.12	0.461
Location × Treatment	N.S	N.S	0.061	0.166	21.39	N.S

Refer to methodology for treatment details.

ranged from 1.16, 226, 1.74 (T_0) to 3.06, 703, 5.30 (T_{10}) respectively. Similar trend was observed at SRS Pampore which ranged from 1.10, 253, 1.65 (T_0) to 3.10, 713, 5.59 (T_{10}) respectively. Average corm number (2.99), average total number of corms/plot (687.50), and average corm weight/plot (5.395 kg) was recorded in T_{10} with an increase of 164%, 164%, and 218% over control respectively (Table 2). Similar results were observed (Kukde *et al*. 2006) in bulb plant. Significant increase was recorded in saffron and corm production over control using FYM, vermicompost and *Azotobacter* (Samad *et al*. 2010) on saffron and corm yield in Srinagar. From the above results, it is concluded that T_7 treatment is best for saffron production under organic conditions as well as for corm production followed by T_9 and T_7. Researchers conducted a factorial experiment in a completely randomized design with three replications in the research farm of the agricultural faculty of Shahid Bahonar University of Kerman in 2017–2018 to investigate the quantitative and qualitative characteristics of saffron stigma, flower, and leaf under the effect of different vermicompost and mycorrhiza levels. For each planting location, two corms of the same weight (7.5 0.5 g) were planted. The investigated factors included vermicompost in 4 levels (0, 8000, 16,000, and 24,000 kg/ha), as well as mycorrhiza inoculation in four levels (0, 7.5, 10 and 15 g). The results showed a significant effect of vermicompost on the leaf area and dry weight, crocin, and picrocrocin in both years (Najmeh *et al*. 2020).

SUMMARY

An experiment was conducted at SKUAST-Kashmir during 2018–19 and field trials were conducted at Dryland Agriculture research Station of SKUAST-K and Saffron Research Station, Pampore, Jammu and Kashmir. Results of the present investigation revealed that application of vermicompost, biofertilizer alone or in combination were beneficial in increasing commercial production of saffron. It encouraged more blossoms, which directly influenced the yield of saffron in both locations. At the Dryland Agriculture Research Station, SKUAST-Kashmir application of *Azotobacter* @11.5 g + 115 g sand + recommended dose of vermicompost of FYM recorded highest number of flowers/plot (139), fresh flower weight (40.10g), and pistil weight (1.17g), followed by treatment level T_6 (*Azotobacter* @11.5 g + 115 g sand + recommended dose of vermicompost of kitchen waste), similar T_{10} (*Azospirillum* @11.5 g + 115 g sand + suggested amount of FYM vermicompost). Similar trends in the results were seen at the Pampore Saffron Research Station. Significant changes between treatments for all the features were found in the analysis of variance for the floral and corm properties. For all features, with the exception of the number of flowers, flower weight, and corm weight, location impacts were also significant.

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