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The influence of controlled release fertilizers and organic amendments on growth and flowering of pot mums (*Dendranthema grandiflora* Tzvelev)

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Abstract
The objective of this study was to find the effect of controlled release fertilizers (CRF), jeevamrit and PGPR on *Dendranthema grandiflora* Tzvelev. The experiments were laid out in 6-inch clay pots with 12 treatments replicated thrice consisting of two genotypes i.e. 'UHFS Chr-56' and 'UHFS Chr-68'. CRF A (7.5 g/pot), CRF B (11.2 g/pot) and jeevamrit @ 5% (250 ml/pot at monthly interval) along with PGPR (KS_5 + KS_6) were used. Out of the two genotypes, plant height, spread, and flower diameter was more in the genotype 'UHFS Chr-68' where as 'UHFS Chr-56' had greater number of flowers and pot present ability score. Application of CRF B (11.2 g/pot) along with jeevamrit @ 5% (250 ml/pot at monthly interval) were effective in increasing the plant height, plant spread, number of flowers per plant and pot present ability score. However, CRF B (11.2 g/pot) + PGPR (KS_5 + KS_6 as root dip method) were effective in increasing the flower diameter.

Keywords: Controlled release fertilizers, jeevamrit, PGPR, potted chrysanthemums

1. Introduction
Potted Chrysanthemums or pot mums (*Dendranthema grandiflora* Tzvelev), belongs to the family Asteraceae is commercially grown throughout the world. It has a year-round demand as a flowering pot plant for decoration. Those cultivars which are well-shaped, branches readily, produces flowers quickly on relatively short stems and has flowers of desired colour, shape and size are suitable as pot mums (Crater, 1995) [4]. A good fertilisation plan is necessary for pot mums to thrive and bloom at their best. It will increase yields, lessen disease issues, and improve flower keeping quality. The three plant nutrients that are most frequently employed during production are nitrogen, phosphorus, and potassium. Typically, these nutrients are supplied as water-soluble fertiliser (WSF). WSF can, however, cause substantial leaching from containers. Controlling the release of nutrients into the soil solution with controlled or slow-release fertilisers is the most efficient technique to ensure that their availability corresponds with plant needs. For container-grown plant production, slow-release fertilisers have been shown to restrict nutrient loss, reduce nutrient runoff, improve nutrient use efficiency, and lower production costs (Haver and Schuch, 1996 and Medina *et al.* 2008) [7, 9]. Additionally, it can replace numerous applications of water-soluble fertilisers with a single application (Guertal, 2009) [6]. These fertilisers are composed of granules covered with a variety of substances, including polylactic acid, wax resin, polyvinyl chloride, and natural rubber copolymer. Primarily, the granules contain NPK. When they come into touch with moist soil, the nutrients are released through the membrane with the help of molecular diffusion. Temperature, pH levels, coating thickness, and other factors affects the rate of their release. Due to the rising usage of chemical fertilizers, land is rapidly becoming infertile. Utilizing organic fertilizers can help to improve the fertility. These fertilisers strengthen the soil's structure and increase its capacity to hold nutrients and water. There will be little to no chance of salts and chemicals accumulation that are hazardous to plants. Utilizing liquid organic fertilisers is a quick and efficient approach to feed plants in fields and pots. The application of Jeevamrit (liquid organic fertiliser) improves the nutrient availability to the crop, protects the plants from disease and increases biological activity in the soil. Enhancing knowledge of interactions between plant populations and microbial populations in the rhizosphere is another way to lessen the negative impacts of chemical fertilisers and the most effective way is by the application of Plant Growth Promoting Rhizobacteria (PGPR). These are the naturally occurring, free-living microorganisms that are important for the development of

environmentally friendly and sustainable agriculture because they promote soil fertility, plant growth, and phytopathogen suppression. Hence, the present investigations were carried out with the objective to study the effects of controlled release fertilizers, Jeevamrit and PGPRs on potted chrysanthemums.

2. Material and Methods

The present investigation on the effect of controlled release fertilizers and organic amendments on pot mum production was conducted at the experimental farm of the department of Floriculture and Landscape Architecture of Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P). The study was conducted on two genotypes of chrysanthemum namely, **'**UHFS Chr-56' and 'UHFS Chr-68' developed in the department of Floriculture and Landscaping Architecture of Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh.

The plants for carrying out the experiment were propagated by using shoot tip cuttings. Clay pots of six inch in size were used for the experiment. The medium was prepared by sieving soil, sand and well rotten farm yard manure separately and mixing in the ratio of 1:1:1 (v/v). The uniform sized rooted cuttings were planted with 1plant/pot. The operation of pinching was performed to produce multi-stemmed plants by removing 2-3 cm apical growing portion of the plant. Pinching was done in both the genotypes thrice.

3. Treatment details

In this experiment polymer coated fertilizers – CRF A (4 months longevity) and CRF B (6 months longevity) containing 15% N, 7% P, 15% K, 2% MgO along with micronutrients were applied @ 7.5 g/pot and 11.2 g/pot, only once respectively, according to treatment specifications. Soil application of 5% Jeevamrit @ 250 ml/ plant was done in monthly interval as per treatment specifications. The rooted cuttings of chrysanthemum were dipped in liquid inoculum KS_5+KS_6, identified as *Bacillus* spp. for half an hour before transplanting.

There are 12 treatments consisting of T_1 (2 g/ litre of 19:19:19 (NPK) @ 500ml per plant at fortnight intervals), T_2 **(**CRF A @ 7.5 g/plant), T_3 **(**CRF B @ 11.2 g/plant), T_4 **(**T_1+ Jeevamrit), T_5 **(**T_2+ Jeevamrit), T_6 **(**T_3+ Jeevamrit**),** T_7 **(**Only Jeevamrit**),** T_8 **(**PGPR + Jeevamrit), T_9 (T_3+ Jeevamrit), T_{10} (Only PGPR), T_{11} (Only Jeevamrit) and T_{12} (PGPR + Jeevamrit). The experiment was laid out in Completely Randomized Design (CRD) (Factorial) with three replications. The experimental data were analysed statistically by applying the technique of analysis of variance (ANOVA) prescribed for the design to test the significance of treatment means and compared at P=0.05 as suggested by Panse and Sukhatme (2000) [10]

4. Results and Discussion

The plant height and spread were recorded at the time of peak flowering which are the important parameters for recommending any cultivar for pot culture, should be proportionate to the height of the pot. It is generally accepted that the height of the plant should be 1.5 to 2.5 times to the height of the pot and its spread should be 1.5 to 2.5 times the diameter of the pot. Therefore, for 6 inch (15cm) earthen pot, the ideal plant height and spread should be in the range of 22.5 to 37.5 cm. Appropriate height and spread of the plants was noted in 'UHFS Chr-68' (28.26 cm) as compared to 'UHFS Chr-56' (24.87 cm) and 'UHFS Chr-68' (30.09cm) as compared to 'UHFS Chr-56' (26.09 cm) respectively. Maximum plant height (32.23 cm) and spread (31.31cm) was recorded with CRF B + jeevamrit @ 5% (T_9). The combination of organic manures and controlled release fertilizers might have helped in better availability and uptake of nutrients by the plants. Similar results are reported in by Asrar *et al.* (2014) [1] in potted chrysanthemum and by Carpio *et al.* (2005) [3] in *Ipomoea carnea* sp *fistulosa*. Similar reports of positive effect of jeevamrit on plant height were reported by George (2012) [5] in gerbera.

Maximum numbers of flowers per plant (96.35) were found maximum in the genotype 'UHFSChr-56' than 'UHFSChr-68' (89.20). This was also reported by Mehta, 2008. Number of flowers per plant increased (140.67) with the application of CRF B + jeevamrit @ 5% (T_9) as compared to all other fertilizer treatments. Similar reports are found in Zhu *et al.* (2009) [12] in *Chrysanthemum morifolium*, Kalmotia (2007) [8], Bloome and Dambre (1980) [2] in Gerbera. Larger flowers were noticed in the genotype 'UHFSChr-68' (4.13cm) as compared to 'UHFSChr-56' (2.76cm). Maximum flower diameter (3.93cm) was noticed with the application of CRF B + PGPR (T_6). Similar findings were also observed by Asrar *et al.* (2014) [1] in potted chrysanthemum and Zhu *et al.* (2009) [12] in *Chrysanthemum morifolium*. Also, Sharma (2015) also reported that application of PGPR consortia (KS_5+KS_6) recorded significant increase in flower size in cv. 'Ajay' and cv. 'Purnima' of Chrysanthemum.

Quality of the plants was evaluated on the basis of point system modified after Conover (1986). The points allotted to each parameter were studied out of 100 points. Lower pot present ability was noticed in 'UHFS Chr-68' (85.85) as compared to 'UHFS Chr-56' (86.29). pots treated with CRF B + jeevamrit @ 5% (T_9) gained maximum (94.07) points. Increase in presentability of pots due to controlled release fertilizer was also observed by Kalmotia (2007) [8] in Gerbera and Carpio *et al.* (2005) [3] in *Ipomoea carnea* spp. *fistulosa.*

Table 1: Effect of Controlled Release Fertilizers (CRF), PGPRs and jeevamrit on chrysanthemum genotypes

Treatments	Plant height			Plant spread			No of flowers			Flower diameter			Pot presentability		
	'UHFS Chr-56' (V_1)	'UHFS Chr-68' (V_2)	Mean	UHFS Chr-56' (V_1)	'UHFS Chr-56' (V_1)	'UHFS Chr-68' (V_2)	Mean	'UHFS Chr-68' (V_2)	Mean	'UHFS Chr-56' (V_1)	'UHFS Chr-68' (V_2)	Mean	'UHFS Chr-56' (V_1)	'UHFS Chr-68' (V_2)	Mean
T_1 = RDF*	22.04	25.84	23.94	24.03	29.08	26.56	78.42	77.16	77.79	2.56	4.11	3.34	80.47	80.65	80.56
T_2 = CRF A	25.24	30.39	27.81	25.79	31.47	28.63	119.35	94.38	106.87	2.90	4.05	3.48	84.67	83.59	84.13
T_3 = CRF B	28.18	28.96	28.57	29.26	30.04	29.65	115.31	101.81	108.56	2.71	4.11	3.41	83.08	82.97	83.03
T_4 = T_1 + PGPR	23.44	24.93	24.19	25.21	26.92	26.07	78.14	60.00	69.07	2.69	4.05	3.37	87.77	88.02	87.89
T_5 = T_2 + PGPR	27.02	29.01	28.02	27.39	31.38	29.39	120.20	119.24	119.71	2.81	4.20	3.51	90.03	89.29	89.66
T_6 = T_3 +	27.52	31.29	29.41	28.11	33.93	31.02	109.80	111.13	110.47	3.01	4.85	3.93	91.70	90.69	91.19

PGPR															
T_7 = T_1 + jeevamrit	23.13	25.90	24.51	25.01	29.43	27.22	72.85	89.56	81.21	2.69	4.07	3.38	90.73	90.03	90.38
T_8 = T_2 + jeevamrit	28.39	34.46	31.43	28.41	34.16	31.29	120.77	115.89	118.33	3.18	4.12	3.65	92.97	92.77	92.87
T_9 = T_3 + jeevamrit	31.40	33.06	32.23	30.27	32.35	31.31	142.23	139.12	140.67	2.75	4.25	3.50	94.43	93.71	94.07
T_{10} = PGPR	23.16	26.70	24.93	24.89	29.46	27.17	84.83	62.44	73.64	2.61	3.94	3.27	80.19	80.08	80.13
T_{11} = jeevamrit	21.88	23.23	22.56	22.26	25.58	23.92	48.77	44.33	46.55	2.51	3.92	3.21	79.15	78.42	78.79
T_{12} = PGPR + jeevamrit	17.06	25.31	21.19	22.41	27.25	24.83	65.51	55.39	60.45	2.67	3.92	3.30	80.28	79.94	80.11
Mean	24.87	28.26		26.09	30.09		96.35	89.20		2.76	4.13		86.29	85.85	
CD $_{0.05}$ Genotype (G)	0.43			0.44			3.58			0.04			0.30		
CD $_{0.05}$ treatments (T)	1.06			1.07			8.78			0.10			0.73		
CD $_{0.05}$ G×T	1.50			1.52			12.41			0.14			NS		

5. Conclusion

From the present investigations, it can be concluded that the combined application of CRF B (11.2 g/plant) and jeevamrit @ 5% (250 ml/ plant at monthly interval) was beneficial in enhancing majority of the characters of commercial importance of the potted chrysanthemums like plant height, spread, number of flowers and pot presentability score. However, flower diameter was observed in the pots with the application of CRF B (11.2 g/pot) + PGPR (KS_5 + KS_6 as root dip method).

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