Impact of growing medium composition on morphological development of chrysanthemum (*Chrysanthemum morifolium* Ramat cv. Snowball)

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The light-weight growing medium compositions were evaluated in the present study for optimum growth and flowering of potted *Chrysanthemum morifolium* Ramat cv. Snowball. Plants were grown in six different potted medium compositions – control: garden soil + (farmyard manure (FYM) 2 : 1), cocopeat + FYM (1 : 1), cocopeat + FYM (2 : 1), vermiculite + FYM (1 : 1), vermiculite + FYM (2 : 1) and cocopeat + vermiculite + FYM (1 : 1 : 1). Results revealed vegetative growth with maximum plant height, number of leaves and root suckers per plant in the case of cocopeat + FYM (2 : 1), whereas flower quality, i.e. duration of flowering and flower diameter was highest in media vermiculite + FYM (2 : 1). Moreover, plants showed significant ($P < 0.05\%$) vegetative growth with better flowering time and quality in cocopeat + vermiculite + FYM (1 : 1 : 1). Therefore, the present findings suggest that for growing potted chrysanthemum cv. Snowball for display, light-weight growing medium composition of cocopeat + vermiculite + FYM (1 : 1 : 1) is the best with better plant morphological development and sustained quality flower production.

Keywords: Chrysanthemum, cocopeat, growing medium, morphological development.

NOW-A-DAYS, with an increased demand for ornamental potted plants within the country and abroad, the need for light-weight growing medium has become more desirable due to its easy portability and shipment during exhibitions and flower shows to foreign countries[1]. Soil supplemented with various light-weight growing media, i.e. cocopeat, leaf mould, farmyard manure (FYM), municipal sewage sludge, vermicompost, etc. alters the physico-chemical characteristics of the growing mixtures and affects plant growth, root system, nutritional status[2] as well as the value of potted ornamental plants[3]. There is evidence for growing chrysanthemum plants in soilless growing media, including perlite, peat, creamsite, rice husk ash[4], soilrite[5], treated coir dust[6], carbonized rice husk[7] and cocopeat + soilrite, cocopeat + compost[8]. The plant height, spread, flower weight and number of flowers in chrysanthemum variety 'Punjab Anuradha' were observed to be maximum in cocopeat + sand + FYM + vermicompost in equal ratio[9]. The cocopeat-based medium combination could replace the traditional potting medium (soil) for pot production in chrysanthemum cv. Sadbhavana[10]. The ability of the growing medium to maintain a healthy balance between water content and gaseous exchange is critical for the keeping quality of many ornamental plants, particularly chrysanthemum[11]. Therefore, we studied the effect of different growing media on morphological development of *Chrysanthemum morifolium* cv. Snowball to standardize the light-weight potting medium with desirable physio-chemical properties for quality flower production.

The experiment was carried out in the Farm Area, Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana during two consecutive years, i.e. 2014–2016. Six different medium compositions were selected and prepared by mixing at different ratios and filled in 8-inch earthen pots uniformly by tapping to maintain equal compaction levels. The terminal cuttings (5–7 cm) were pinched (taken) from mother stock plants in the end of May were treated with rooting hormone indole butyric acid (IBA) (400 mg/l) and planted in burnt rice husk/sand for rooting in June–July under shade. The rooted cuttings were transplanted individually in July–August in the earthen pots filled with growing medium compositions. The growing medium combination treatments are as follows: T_1 (control: garden soil + FYM (2 : 1)), T_2 (cocopeat + FYM (1 : 1)), T_3 (cocopeat + FYM (2 : 1)), T_4 (vermiculite + FYM (1 : 1)), T_5 (vermiculite + FYM (2 : 1)) and T_6 (cocopeat + vermiculite + FYM (1 : 1 : 1)). After the cuttings were transplanted, liquid fertigation of 300 ppm nitrogen and 200 ppm potassium was applied at 15 days interval till mid-October; thereafter, 200 ppm of nitrogen and potassium each was applied for the remaining months. The weeds were removed manually and plants were watered regularly depending upon the season. Disbudding, the removal of axillary buds, was done at the end of November by retaining the terminal bud for large-sized terminal flower. Staking was done with single stake to provide vertical support to keep the plants erect and maintain proper shape of plant and bloom. Suckers were separated when 4–5 green leaves appeared and planted at a spacing of 30 × 20 cm in the field during February–March. Diethane M-45 @ 0.3% and Rogor or Malathion @ 0.3% were sprayed at fortnightly intervals to control diseases and insect attacks respectively.

The experiment was conducted according to treatments in completely randomized design (CRD) with three replications comprising five pots per replication. The observations, i.e. vegetative and flower parameters were recorded during the two years (2014–16) and analysed statistically using SAS software. The treatment means were compared

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Table 1. Effect of medium composition on plant height (cm) of *Chrysanthemum morifolium* cv. Snowball

	30 DAP			45 DAP			60 DAP			75 DAP		
Treatment (medium composition)	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
Garden soil: FYM (2 : 1)	10.25c	9.91c	10.08c	24.25c	20.88d	22.56d	47.42c	45.09c	46.25c	60.26d	59.59d	59.92d
Cocopeat + FYM (1 : 1)	12.45ab	11.99ab	12.22ab	28.99a	27.99a	28.49a	52.20ab	51.20a	51.70ab	69.64ab	68.97a	69.31a
Cocopeat + FYM (2 : 1)	13.45a	12.78a	13.11a	29.14a	28.81a	28.98a	53.57a	51.90a	52.73a	70.33a	69.67a	70.00a
Vermiculite + FYM (1 : 1)	11.26bc	10.63bc	10.95c	26.74b	25.97b	26.36b	50.90ab	48.90b	49.90ab	62.85c	62.52c	62.69c
Vermiculite + FYM (2 : 1)	11.02bc	10.39bc	10.71c	25.05c	24.71c	24.88c	49.74bc	48.74b	49.24bc	62.69c	61.69cd	62.19c
Cocopeat + vermiculite + FYM (1 : 1 : 1)	12.39ab	11.73ab	12.06b	28.52a	27.85a	28.19a	52.96ab	50.96a	51.96ab	67.69b	66.99b	67.34b
F-test	*	*	*	*	*	*	*	*	*	*	*	*
CD	1.64	1.48	1.00	1.29	1.18	2.60	3.05	1.37	3.01	2.02	1.82	1.21

DAP, Days after planting.

Table 2. Effect of medium composition on number of leaves per plant of *C. morifolium* cv. Snowball

	30 DAP			45 DAP			60 DAP			75 DAP		
Treatment (medium composition)	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
Garden soil + FYM (2 : 1)	9.57d	8.91d	9.24d	12.7d	11.70d	12.20c	20.41d	19.74c	20.07b	24.13d	23.80b	23.96c
Cocopeat + FYM (1 : 1)	11.56b	11.23ab	11.39b	15.49ab	15.82a	15.66a	26.74ab	24.97a	25.85a	31.98a	29.65a	30.82a
Cocopeat + FYM (2 : 1)	12.76a	11.99a	12.37a	16.43a	15.76a	16.10a	27.76a	25.99a	26.87a	32.39a	29.92a	31.16a
Vermiculite + FYM (1 : 1)	10.80bc	10.47bc	10.63bc	13.92c	13.59bc	13.76b	23.24c	21.91b	22.57b	27.78bc	25.78b	26.78bc
Vermiculite + FYM (2 : 1)	10.25cd	9.92c	10.09cd	13.48cd	12.48cd	12.98bc	22.97c	20.97bc	21.97b	26.68c	25.34b	26.01bc
Cocopeat + vermiculite + FYM (1 : 1 : 1)	11.32bc	10.99b	11.16b	15.11b	14.78ab	14.95a	25.93b	24.60a	25.27a	30.02ab	27.95a	28.98ab
F-test	*	*	*	*	*	*	*	*	*	*	*	*
CD	1.03	0.78	0.85	1.15	1.28	1.17	1.54	1.54	2.66	2.40	2.08	3.29

Mean values in each column with the same letter are not significantly different (i.e. at par), whereas, with different letters (a, b, c, d) are significantly different at $P < 0.05$ according to DMRT. The letters bc is at par with b and c and significantly different from other letters. Similarly for the other letters ab, cd. *Significant at $P < 0.05$.

using Duncan multiple range test (DMRT) at 5% level of significance[12].

The different physical and chemical properties of growing medium compositions were determined to identify factors that affect the morphological development of chrysanthemum plants. The medium samples were used for determination of pH (1 : 2 medium : water suspension), electrical conductivity (EC; 1 : 2 media : water suspension; dS m^{-1}), maximum water-holding capacity (WHC; %) using Keen's box[13], bulk density (BD; g/cm^3) using the soil core method[14] and total nitrogen (%) by Kjeldahl's method[15].

In *Chrysanthemum morifolium* cv. Snowball, the different growing medium compositions significantly ($P < 0.05$) influenced plant height, number of leaves at 30, 45, 60 and 75 days after planting (DAP) and root suckers per plant (Tables 1–3). Plant height at 30, 45, 60 and 75 DAP varied significantly among the different medium compositions, with minimum in T_1 (10.08, 22.56, 46.25 and 59.92 cm respectively) and significantly ($P < 0.05$) maximum in T_3 (13.11, 28.98, 52.73 and 70.00 cm respectively). The plant height recorded at 45 and 60 DAP in T_3 was followed by T_2 (28.49 and 51.70 cm respectively) and T_6 (28.19 and 51.96 cm respectively) both of them were at par among themselves. Plant height observed at 75 DAP in T_3 (70.00 cm) was followed by T_2 (69.31 cm), both were at par among themselves. The number of leaves at 30, 45, 60 and 75 DAP was significantly better in T_3 (12.37, 16.10, 26.87 and 31.16 respectively) and minimum in control (9.24, 12.20, 20.07 and 23.96 respectively). The number of leaves recorded at 30, 45 and 60 DAP in T_3 was followed by T_2 (11.39, 15.66 and 25.85 respectively) and T_6 (11.16, 14.95 and 25.27 respectively), at par among themselves. The number of leaves 75 DAP were recorded highest in T_3 (31.16) followed by T_2 (30.82), both of which were at par among themselves. The number of root suckers per plant was significantly better in T_3 (12.10) followed by T_2 (10.93) and T_6 (10.70), both of them at par among themselves and minimum in control (8.57).

Vegetative growth was recorded higher in cocopeat-based medium compositions with maximum in cocopeat + FYM (2 : 1). This could be due to its better physiochemical characteristics, including lower bulk density, higher total porosity, water-holding capacity and higher nitrogen availability to the plants[16]. The superiority of cocopeat over other pot mixtures has been reported earlier in pothos[17] and roses[18]. The highest values of leaf number and shoot length in pothos were observed in medium containing cocopeat only[19]. A significant increase in leaf number of pot anthurium has also been reported using coir dust[20].

In *C. morifolium* cv. snowball, the medium compositions significantly ($P < 0.05$) influenced days to bud appearance, colour break stage and full bloom, duration on flowering, flower diameter, number of flowers per plant and nitrogen content in plants. Flower bud appearance, colour break stage and full bloom were delayed with medium compositions amended with cocopeat (Table 4). The days to flower bud appearance, colour break stage and full bloom were maximum in T_3 (68.87, 82.14 and 116.34 days respectively) and minimum in control (62.68, 74.86 and 107.22 days respectively). The days to flower bud appearance were maximum in T_3 (68.87 days) was followed by T_2 (68.01 and 67.89 days) and T_6, both of them at par among themselves. The days to colour break stage were maximum in T_3 (82.14 days) followed by T_2 (81.23 days) both of them were at par among themselves. The duration of flowering, flower diameter and nitrogen content differed significantly among different medium compositions in the plants (Table 3). The duration of flowering, flower diameter and nitrogen content in plants were found minimum in control (11.81 days, 13.89 cm and 0.86% respectively). The duration of flowering was significantly better in T_5 (14.16 days) followed by T_6 (13.11 days). The minimum duration of flowering obtained in control was at par with T_2 (12.13 days). The flower diameter was maximum in T_5 (17.14 cm) followed by T_4 (16.63 cm), both of them were non-significantly different. The nitrogen content in plants was highest in T_3 (1.42%).

The more number of days taken to flowering in plants grown in cocopeat-based medium mixtures could be due to higher availability of nitrogen in these medium compositions, which encourages vegetative growth with delayed reproductive stage. The duration of flowering and flower diameter showed superiority of vermiculite-based potting medium over other medium compositions, with highest in vermiculite + FYM (2 : 1). This might be due to higher availability of potassium in vermiculite-based medium mixture compared to the other mixtures. These results are supported by significant increase in flower size by the application of urea with a combination of potash and FYM in dahlia[21].

The physical and chemical characteristics, viz. BD, WHC and total nitrogen greatly differed among different treatments (Table 5). Figure 1 shows the effect of medium composition on BD and WHC. Cocopeat + FYM (2 : 1) recorded the highest WHC (338.28%), whereas the lowest value (30.16%) was recorded in garden soil + FYM (2 : 1). The highest value of BD (1.10 g/cm^3) was recorded in garden soil + FYM (2 : 1) and the lowest (0.16 g/cm^3) in cocopeat + FYM (2 : 1). The maximum value of total nitrogen (1.48%) was obtained in cocopeat + FYM (2 : 1) whereas the minimum (0.20%) was obtained in garden soil + FYM (2 : 1).

The physical properties of growing media like aeration and WHC are the most important factors, while among the chemical characteristics, nutritional status and salinity level play a crucial role in plant development[22]. The availability of higher nitrogen content as a source of nutrition with lower BD, higher porosity and WHC in

Table 3. Effect of media composition on flower quality, root suckers and nitrogen content of *C. morifolium* cv. Snowball

Treatments (medium composition)	Flower diameter (cm)			Duration of flowering (days)			No. of root suckers/plant			N content in plants (%)
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	Pooled
Garden soil + FYM (2 : 1)	14.22c	13.56c	13.89c	12.31b	11.31c	11.81c	8.85c	8.29d	8.57d	0.86f
Cocopeat + FYM (1 : 1)	14.96c	14.29bc	14.63bc	12.29b	11.96bc	12.13c	11.10ab	10.76b	10.93b	1.28b
Cocopeat + FYM (2 : 1)	15.46bc	14.46bc	14.96bc	12.95ab	12.61ab	12.78bc	12.27a	11.94a	12.10a	1.42a
Vermiculite + FYM (1 : 1)	16.96a	16.3a	16.63a	13.94ab	13.27a	12.61ab	9.84bc	9.51c	9.67c	0.95d
Vermiculite + FYM (2 : 1)	17.30a	16.97a	17.14a	14.66a	13.66a	14.16a	9.43bc	9.10c	9.26c	0.89e
Cocopeat + vermiculite + FYM (1 : 1 : 1)	16.47ab	15.13b	15.08ab	13.45ab	12.78ab	13.11abc	10.86ab	10.53b	10.70b	1.04c
F-test	*	*	*	ns	*	*	*	*	*	*
CD	1.23	1.09	1.45	ns	1.00	1.24	1.56	0.75	0.65	0.15

Mean values in each column with the same letter are not significantly different (i.e. at par), whereas, with different letters (a, b, c, d) are significantly different at $P < 0.05$ according to DMRT. The letters bc is at par with b and c and significantly different from other letters. Similarly for the other letters ab, cd. ns, Non significant. *Significant at $P < 0.05$.

Table 4. Effect of medium composition on flowering time of *C. morifolium* cv. Snowball

Treatment (medium composition)	Days to bud appearance			Days to colour break stage			Days to full bloom		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
Garden soil + FYM (2 : 1)	62.52c	62.85d	62.68b	75.2d	74.53d	74.86d	108.22d	106.22d	107.22d
Cocopeat + FYM (1 : 1)	68.67a	67.34b	68.01a	81.9ab	80.56a	81.23a	116.79a	113.12ab	114.95ab
Cocopeat + FYM (2 : 1)	69.03a	68.70a	68.87a	82.47a	81.80a	82.14a	117.84a	114.84a	116.34a
Vermiculite + FYM (1 : 1)	64.78b	64.44c	64.61b	77.48cd	76.81c	77.14c	111.15c	109.48c	110.31bcd
Vermiculite + FYM (2 : 1)	64.74b	63.40d	64.07b	76.77cd	76.44c	76.61c	110.87c	108.87c	109.87cd
Cocopeat + vermiculite + FYM (1 : 1 : 1)	68.89a	66.89b	67.89a	79.50bc	78.83b	79.17b	114.94b	111.61b	113.28abc
F-test	*	*	*	*	*	*	*	*	*
CD	1.90	1.03	1.98	2.65	1.68	1.36	1.82	1.86	4.70

Table 5. Physico-chemical characteristics of medium composition

Treatment (media composition)	pH	EC (dS/m)	D (g/cm^3)	WHC (%)	Total N (%)
Garden soil + FYM (2 : 1)	7.79	0.246	1.10	30.16	0.20
Cocopeat + FYM (1 : 1)	7.41	0.639	0.21	245.66	1.31
Cocopeat + FYM (2 : 1)	7.60	0.484	0.16	338.28	1.48
Vermiculite + FYM (1 : 1)	7.58	0.282	0.48	140.21	0.44
Vermiculite + FYM (2 : 1)	7.79	0.483	0.44	95.32	0.28
Cocopeat + vermiculite + FYM (1 : 1 : 1)	7.61	0.473	0.31	207.78	1.29
F-test	ns	*	*	*	*
CD	ns	0.11	0.17	5.72	0.12

EC, Electrical conductivity; BD, Bulk density; WHC, Water-holding capacity.

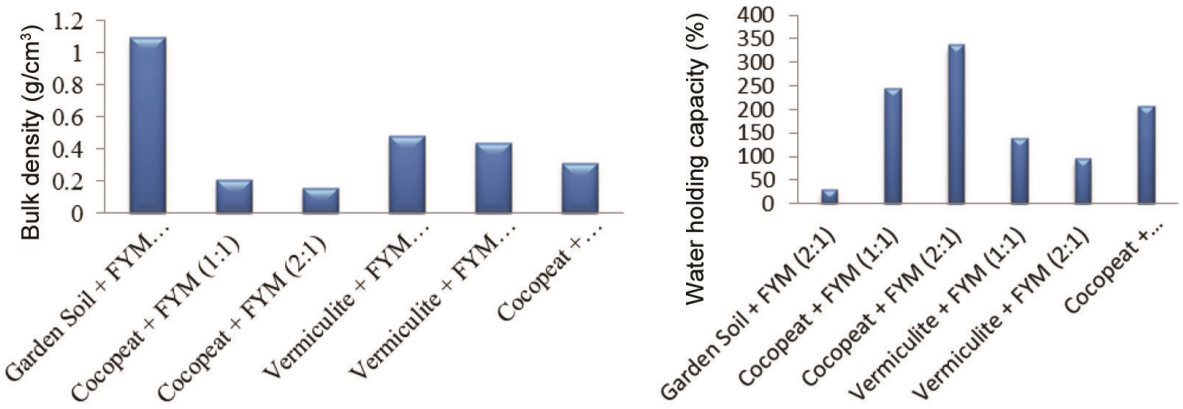

Figure 1. Effect of media compositions on bulk density (g/cm^3) and water-holding capacity (%).

cocopeat-based medium mixtures might be the reason for better plant growth and flower production, as reported earlier in chrysanthemum[10]. As pot weight is an important factor during transport and shipping, and soil is heavy and prone to diseases, may get compacted after potting. Hence, cocopeat-based medium compositions could replace the traditional potting medium (soil) for chrysanthemum production[10].

The medium combination of cocopeat + FYM (2 : 1) resulted in the best vegetative growth, however, there was delay in time of flowering and deterioration in flower quality. The flower quality parameters, i.e. duration of flowering and flower diameter were best in case of vermiculite + FYM (2 : 1), but showed poor vegetative growth. Moreover, plants showed significant ($P < 0.05\%$) vegetative growth with better flowering time and quality in cocopeat + vermiculite + FYM (1 : 1 : 1). Therefore, the present findings suggest that for growing potted chrysanthemum cv. Snowball for display, light-weight growing medium composition of cocopeat + vermiculite + FYM (1 : 1 : 1) is the best option with better plant morphological development and sustained quality flower production.

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