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Performance of cocopeat amended media mixtures on growth and flowering of chrysanthemum

Simrat Singh[1]*, R.K. Dubey[1] and S.S. Kukal[2]

[1]*Department of Floriculture and Landscaping,* [2]*Department of Soil Science, Punjab Agricultural University, Ludhiana-141004, India.*E-mail: simrat1020@gmail.com*

Abstract

Restricted pot volume and inadequate gaseous exchange in root zone environment restricts satisfactory growth and development of chrysanthemum plants. To this effect, an experiment was conducted to study the performance of cocopeat amended media mixtures in improving the root zone environment for satisfactory growth and flowering of chrysanthemum. The growing media mixtures such as farm yard manure and leaf mould as base media (25%) were amended with varying proportions each of soil: cocopeat (CP) as 75%:0; 50%:25%; 25%:50% and 0%:75% on volume basis. The media mixtures amended with increasing proportion of CP lowered the pH, bulk density, particle density and weight of the pots. The plants raised in media mixtures with increasing proportions of CP were observed to be well anchored and exhibited excellent quality of flowers. Utilizing 75% CP as a growing media amendment in FYM proved to be the best media mixture for ideal growth and performance of potted chrysanthemum. Better aggregate stability provided by the base media and increased K content in CP coupled with improved physical characteristics of media mixtures provide a suitable reason to utilize CP as a alternative light weight potting media for an ideal display of pot mums.

Key words: Chemical properties, cocopeat, farm yard manure, leaf mould, potted chrysanthemum, physical properties

Introduction

Chrysanthemums (commonly known as pot mums) have been widely acclaimed as a popular potted plant due to wide range of flower colour, flower types and long flowering duration. Chrysanthemum ranks 3rd among cut flowers and 5th among the potted plants around the world (Attavar and Bhat, 1995). Growing chrysanthemum in plastic containers or earthen pots pose a challenge for nurserymen to obtain blooms of exceptional quality due to restricted volume of pots. The major requirement of potted ornamental is light weight of the pots so as to improve their portability for displays. This needs to amend the soil in the pots with various light weight media *viz.* cocopeat (CP), leaf mould (LM), farm yard manure (FYM), municipal sewage sludge (MSS), vermicompost (VC) *etc*. as these media mixtures alter the physico-chemical characteristics of the growing media mixtures. The quality production of container-grown ornamental plants requires a growing media mixture with appropriate composition of suitable amendments for the optimum physical and chemical root zone environment (Vendrame *et al*., 2005). The physical characteristics of growing media primarily affect aeration and water retention status that are essential to maintain equilibrium between moisture content and gaseous exchange in a limited volume of a pot (Kukal *et al*., 2012). Among the physical characteristics total porosity and water holding capacity are probably the most important factors while chemical characteristics such as pH, EC and nutritional status of the media mixture play a crucial role in the plant development (Verhagen, 1997; Dewayne *et al*., 2003).

Growing media mixed with suitable amendments have successfully been utilized for growing ornamental bedding plants (Strojny and Nowak, 2004), *Celosia cristata* (Awang *et al*., 2009), *Codiaeum variegatum* (Younis *et al*., 2010), *Dahlia coccinia* (Younis *et al*., 2007; Younis *et al*., 2008), *Begonia semperflorens* (De Kreij C and Van Leeuwen, 2001) and *Rosa hybrida* (Quintero *et al*., 2009). At the same time, it is essential to maintain the proportion of various base media (such as FYM, LM, MSS, VC) below 50% by volume so as to reduce the potential risk of high salinity as is evident from the findings of Raymond *et al*. (1998). Mixing base media in high proportions by volume is detrimental to plants that may wilt due to higher temperature in media mixture as a result of decomposition of base media. Normally the fraction of compost in the media mixture should not exceed 50% as suggested by Raviv (2011). This necessitated the blending of base media with a suitable amendment so as to maintain and improve the media physical and chemical properties. Base media corresponds to growing media obtained as a natural by-product without fermentation or any amendment so as to alter its physico-chemical composition.

Cocopeat (CP) - an organic by-product from coir industry obtained after the extraction of fiber from the coconut husk is being viewed as a light weight substitute of sphagnum peat in ornamental plant nurseries (Yau and Murphy, 2000; Pickering, 1997). The CP is light in weight with low shrinkage, low bulk density and has slow biodegradation with longer decomposition time (10 years). The CP can be effectively recycled and has acceptable pH (5.2-6.8) (Evans *et al*., 1996; Prasad, 1997). Cocopeat contains soluble salts of chloride and sodium as well as higher contents of K. The concentration of N (0.43%) and P (0.38%) have been reported in cocopeat, but nutrient content varies with the extent of decomposition and method of retting of CP (Solaimalai *et al.*, 2001). Although utilization of CP as a growing media mixture at higher proportions (>50%) cause immobilization of N which is viewed as an unavoidable consequence of biological activity of micro-organisms that consume carbon available in the media

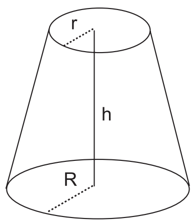
(Arenas *et al.*, 2002). Cocopeat needs to be amended with suitable organic composts so as to maintain optimum nutrient status in growing media for satisfactory growth of plants.

The present study was therefore undertaken with a hypothesis to obtain light weight potting media mixture made from organic wastes to alter the physical and chemical nature of the limited root-zone environment and to generate a logical understanding about the interaction of edaphic factors for growth and development of chrysanthemum.

Materials and methods

Plant materials and experimental treatments: The present investigation was carried out at Punjab Agricultural University Landscape nursery during the period 2011-2012. Two base media *viz.* FYM and LM (25%) were mixed in different media amendments comprising soil and CP in varying proportions (0%, 25%, 50%, 75%) of each on volume basis. To quantify the media volumetrically, the volume of pot (3588 cm^3) was computed mathematically as follows:

$V = \pi h/3(R^2+r^2+Rr)$



Where,

π =constant (3.14);
r =radius of bottom of the pot (6 cm);
R =inner radius of pot (10 cm);
h =height of the pot (17.5 cm)

Quantity of base media and media amendment required to fill in the pot was calculated by multiplying the cubic centimeter space (in their respective ratios) occupied by each of the media in a pot with their respective bulk densities. The resultant media mixtures comprised eight treatments *viz.* (i) (FYM + 75% soil); (ii) (FYM + 50% soil + 25% CP); (iii) (FYM + 25% soil + 50% CP); (iv) (FYM + 75% CP); (v) (LM + 75% soil); (vi) (LM + 50% soil + 25% CP); (vii) (LM + 25% soil + 50% CP) and (viii) (LM + 75% CP). Earthen pots of size 20 cm internal diameter, 12 cm bottom diameter and height of 17.5 cm (top to bottom) were filled with mixtures of different growing media. Proper care was taken to fill all the pots uniformly by tapping to maintain equal compaction levels. The rooted cuttings of chrysanthemum variety 'Mother Teresa' [(US Patent # PP 13,678, assignee- Council of Scientific and Industrial Research (CSIR), New Delhi, India] of uniform size (approximately 5 cm) and age (approximately 30 days), were transplanted (one seedling per pot) in second week of August. This variety was exclusively selected on account of its dwarf, bushy and compact round shape ideal for pot cultivation without need for neither 'Pinching' nor 'Staking'. Weeding was done manually with hand hoe and the plants were inspected daily. Pots were watered with similar amounts at an interval of 4-5 days during months of August-October and thereafter at weekly intervals due to onset of low temperature and cloudy days. Urea nitrogen (N) was applied in two splits – first 4 weeks after transplanting and second dose three weeks thereafter. The mean temperature during the course of the experiment varied from 5-34°C. Dried and shriveled buds/flowers were periodically removed to encourage more bud initiation for longer duration of flowering with quality blooms. No staking or pinching was done as the chrysanthemum variety 'Mother Teresa' is ideally suited for pot culture exhibiting a compact canopy with sturdy stems.

Table 1. Chemical characteristics of media mixtures amended with different proportions of cocopeat

Base media (%, v/v)	Media amendments Soil:cocopeat (%, v/v)	pH	EC (dS/m)	N (%)	P (%)	K (%)
FYM (25%)	75:0	7.55	0.284	0.54	0.22	1.91
	50:25	7.32	0.483	0.50	0.28	3.27
	25:50	7.10	1.170	0.42	0.36	3.42
	0:75	6.85	2.310	0.31	0.44	4.43
LM (25%)	75:0	7.36	0.374	0.32	0.82	1.14
	50:25	7.27	0.404	0.20	1.03	1.31
	25:50	7.29	0.468	0.18	2.19	3.07
	0:75	7.00	1.056	0.11	2.80	4.00

Physical and chemical analysis of media mixtures: Media mixtures were analyzed for physical and chemical properties using standard protocols. These were analyzed for pH, EC, bulk density (Db), particle density (Dp), total porosity and available N, P, and K.

The pH was determined in suspension by mixing 10 g of mixture with 50 mL distilled water. The EC was measured in the same suspension after 24 h in supernatant solution.

The air-dried media samples were used for specific determination of maximum water holding capacity (WHC) (using Keen's box of 5.0 cm diameter and 4 cm high with perforated bottom and a filter paper disc fixed with a steel ring at the bottom end). The bulk density (Db) ($Mg\ m^{-3}$) was determined using the soil core method (Blake and Hartge, 1986). The particle density (Dp) ($Mg\ m^{-3}$) was determined using pycnometer method and total porosity was computed using the following equation:

$\%\ f = (1\text{-}Db/Dp) \times 100$

Where, 'f' is total porosity (%), Db and Dp are bulk density and particle density ($Mg\ m^{-3}$).

The air filled porosity (fa) was determined at field capacity moisture content as per the following equation:

$fa = (f-\theta)$

where, 'f' is the total porosity (%) and θ is the volumetric moisture content at field capacity (%).

The estimation of N was carried after digestion of samples as suggested by Subbiah and Asija (1956). The available phosphorus (P) was determined on spectrophotometer at 760 µm wavelength after shaking the media with extractant and filtering the suspension. The potassium (K) in the media was determined after digestion of media mixture and filtering the suspension for recording reading on flame photometer at 420 µm.

Observations: The observations on morphological parameters such as plant height (cm), plant spread (cm), days to bud appearance, number of flowers/plant per pot, were recorded at full bloom stage. Days to flowering duration were recorded from the appearance of 50% buds showing colour till 50% of the flowers showing withering.

Statistical analysis: The experiment was laid out in a completely randomized block design (CRD) with three replications. The data was analyzed using analysis of variance (ANOVA) to calculate least square difference (LSD, *P*=0.05) (Steel and Torrie, 1960).

Results and discussion

Chemical and physical properties of media mixtures: The pH of media mixture decreased with increasing proportions of CP and decreasing proportions of soil on volume basis keeping the proportions of base media (FYM and LM) as constant. The pH ranged from 7.36-6.85 in different media mixtures compared to 7.55 in control. The pH of the media after addition of media amendments decrease to the extent of 0.19-0.70 units with respect to control (7.55). The higher reduction in pH was observed at highest proportions of CP (75%) whereas lowest reduction was observed in media containing LM amended with 75% of soil without any addition of CP. The addition of coir maintained the pH values within the acceptable limits for optimal plant growth (Fitzpatrick *et al*., 1998). With subsequent additions of CP, the pH of the growing media decreased due to the inability of the organic media to resist the changes in the acidification of the growing medium (Agro and Fisher, 2008) primarily due to poor buffering capacity of the organic substrates. The decrease in pH of the media mixture is considered to be beneficial as the solubility of many nutrients gets reduced at higher pH. As a result, these nutrients are precipitated and are thus rendered unavailable to the plants (Altland, 2006).

The EC of the media mixtures increased with increasing proportions of CP. The EC was highest (2.310 dS/m) in media mixture containing FYM amended with highest proportion (75%) of CP compared to 0.284 dS/m in the control treatment. The increase in EC was observed to be highest (2.026 units) at highest proportion of CP in the media mixture comprising FYM. However, lowest increase in EC (0.682 units) was observed in media mixture containing LM amended with 75% CP compared to control. The EC indicates total inorganic ion concentration in the growing media. Media mixtures with low EC values did not contain excessive salts which are otherwise detrimental to plants. EC of media mixtures of potted chrysanthemums have been recommended ranging from 0.8-1.5 mS/cm (during root establishment), 1.7-3.0 mS/cm (during the growing period), and 0.8-1.5 mS/cm (during reproductive stage) (Aris Horticulture, 2010). The CP being slightly acidic (5.2-6.3) with higher conductivity (0.75-1.99 dSm^{-1}) tended to acidify the pH of the media and increase the EC upon subsequent addition by volume. However, higher conductivity of CP did not affect the plant vigour due to continuous leaching of excessive salts with repeated irrigations. The pH and EC of the growing media markedly affected the growth of plants as these parameters directly influence the uptake of nutrients and salinity levels in the media.

Bulk density decreased correspondingly with additions of CP compared to control (Fig.1). The bulk density decreased by 74.1-5.0% in media mixtures containing varying proportions of CP. The highest decrease in bulk density was observed in media containing FYM amended with highest proportion of CP. The media mixture containing LM as base media amended without CP showed lowest decrease in bulk density. Though the media with low bulk density is not ideal to provide proper anchorage to plants that would result in their lodging (Holcomb, 1994), still the observations in the present experiment revealed that mixing CP in increased proportions provided adequate anchorage to plants due to better aggregate stability provided by the base media (FYM and LM) and soil in respective proportions. Also, low bulk density of CP eased in media mixing and subsequent handling of the pots due to their light weight. The increasing amount of CP in both base media resulted in decrease in mean pot weight from 6.0-4.25 kg (FYM) and 5.6-4.25 kg (LM) (Table 2).

The total porosity increased with increasing proportions of CP in each of the base media ranging from 48.7-80.1% in FYM and 51.4-78.8% in LM. The total porosity increased by 53.3% over control (without addition of CP) in media mixture containing LM amended with highest proportion of CP. However, the lowest increase in total porosity was recorded at 5.54-16.3% in each of the media mixture containing FYM and LM as base media amended with 25% CP, respectively compared to 75% soil. The air filled porosity was also observed in the acceptable limits (25-30%) with subsequent additions of coir in each of the base media mixtures. However, the magnitude of increase was more pronounced in LM compared to FYM. Increase in air filled porosity of media mixture with increasing proportion of cocopeat resulted in better drainage of water and maintained adequate air-water balance in the finite volume of pot. Improved per cent air filled porosity resulted in availability of more space for the roots to proliferate thereby ensuring better uptake of nutrients in a limited volume of potting media. Physical characteristics such as aeration and drainage of media have been found to improve

Table 2. Physical characteristics of media mixtures amended with different proportions of cocopeat

Base Media (%, v/v)	Media amendments Soil:cocopeat (%, v/v)	Mean weight of pots (kg)	Water holding capacity (%)	Total porosity (%)	Moisture content at FC ($cm^3 cm^{-3}$)	Air filled porosity (%)
FYM (25%)	75:0	6.00	39.4	48.7	4.14	20.5
	50:25	5.27	64.5	51.4	5.59	23.9
	25:50	5.00	103.0	62.5	6.76	25.1
	0:75	4.25	300.0	80.1	8.14	33.6
LM (25%)	75:0	5.60	49.9	51.4	4.98	23.0
	50:25	4.75	59.7	59.8	4.28	35.3
	25:50	4.50	57.2	61.1	6.35	37.8
	0:75	4.25	181.1	78.8	6.81	39.9

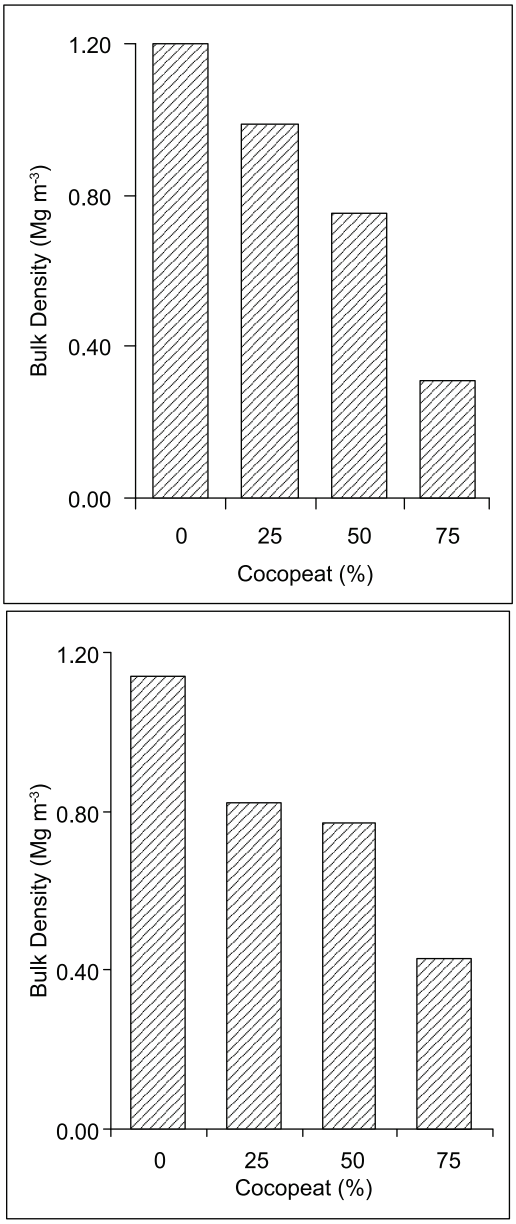


Fig. 1. Bulk density (Db) of FYM (a) and LM (b) based media mixtures amended with cocopeat

in coir based mixtures resulting in better aeration status, water balance of the substrate (Eleni *et al*., 2001; Noguera *et al*., 2000) which are critical for proliferation and development of roots. The addition of CP as media amendment decreased the weight of media mixture contained in the pot. The weight of the pots decreased to the extent of 29.1-24% in FYM and LM, respectively with the addition of CP at highest proportion compared to control. The CP being hydrophilic in nature rehydrates easily and helps to redistribute the moisture towards the surface of the media exposed to evaporation (Cresswell, 1992). It also ensures adequate drainage due to the presence of large number of macropores (macro-porosity) that are conducive to maintain proper aeration status in the media mixture. Handreck and Black (2007) also reported that CP contains more fraction of larger pores that help in drainage of excess water thereby maintaining proper aeration in growing media.

The maximum per cent WHC also increased with increasing proportions of CP. The per cent WHC ranged from 59.7-300% with the addition of CP compared to 39.4% WHC recorded in control. It was highest in media mixture comprising FYM as base media amended with 75% CP and lowest in LM media mixture containing 75% soil as an amendment without any addition of CP. The addition of CP in higher proportions increased the total porosity that resulted in profuse branching of roots, providing better anchorage to plants. The higher WHC of CP-based growing media has been reported due to its higher total porosity as reported by Evans *et al*. (1996) and Prasad (1997).

The amount of moisture content at field capacity (FC) for different media increased with increase in proportion of CP (25%, 50%, 75%) on volume basis. It was found lowest in control treatment (4.14 cm^3cm^{-3}) whereas same media amended with highest proportion of CP had 2-fold increase in FC moisture content. Similar trend was observed in media mixture comprising LM. At

Table 3. Growth and flowering characteristics of chrysanthemum in media mixtures amended with different proportions of cocopeat

Base media (BM) (25% by volume)	Soil:Cocopeat (%, v/v)				
	75:0	50:25	25:50	0:75	Mean
	Plant height (cm)				
FYM	25.9	26.3	27.7	31.4	27.8
LM	30.2	26.0	26.0	22.0	26.0
Mean	28.0	26.1	26.9	26.7	
LSD (0.05)	BM = 1.28; A = NS; BM x A = 2.56				
	Plant spread (cm)				
FYM	28.2	30.0	31.8	34.0	31.0
LM	27.9	26.0	24.0	18.6	24.1
Mean	28.1	28.0	27.9	26.3	
LSD (0.05)	BM = 1.22; A =NS; BM x A =2.45				
	Days to bud appearance				
FYM	72.3	75.0	75.0	76.1	74.6
LM	71.0	74.0	75.0	76.0	74.0
Mean	71.6	74.5	75.0	76.0	
LSD (0.05)	BM = NS; A = 2.73; BM x A = NS				
	Days to Colour show stage				
FYM	94.6	97.3	100.6	103.1	98.9
LM	91.8	91.5	95.4	98.6	93.9
Mean	93.2	94.4	98.0	100.8	
LSD (0.05)	BM = 2.24; A = 3.18; BM x A = NS				
	Number of flowers				
FYM	102.6	120.0	134.2	144.5	125.6
LM	128.3	103.6	96.0	74.0	100.5
Mean	115.5	112.1	115.1	109.3	
LSD (0.05)	BM = 4.29; A =NS; BM x A =8.58				
	Flowering duration (Days)				
FYM	30.6	32.1	35.5	36.3	33.6
LM	34.3	35.6	36.4	41.3	36.9
Mean	32.4	33.8	35.9	38.8	
LSD (0.05)	BM = 2.03; A = 2.88; BM x A = NS				

* BM – Base media; A- Amendments; FYM – Farm Yard Manure; LM – Leaf Mould

75% CP, the media mixture comprising LM had 36.7% higher moisture content at FC compared to media mixture amended with sole soil. However, the FC moisture content in FYM-based media mixture amended with highest proportion of coir showed 19.5% more availability of moisture content at FC compared to LM at same proportion of CP.

Growth and development of chrysanthemum plants: The analysis of variance showed significant differences ($P<0.05$) in vegetative and floral characters of chrysanthemum plants raised in base media (BM: FYM and LM), media amendments (MAs: Soil:CP) in different ratios and their interaction with the base media (Table 3). Chrysanthemum plants raised in base media comprising FYM significantly recorded higher mean plant height then those grown in LM. Though, the height of plants increased with increased proportions of CP by volume, however the differences in the mean plant height was found in-significant with respect to media amendment. The plant height was lowest in control (FYM+75% soil) pots. This could be attributed to unfavourable physical root zone environment caused by lower air filled porosity that may lead to compaction of the media in a pot causing hindrance in root proliferation and nutrient uptake. These results are in accordance with findings of Treder (2008) who recorded increase in plant height in media mixture containing higher proportions of CP. Interaction of base media (BM) and media amendment (MAs) revealed that the plant height tended to increase by 21.2% in FYM and showed a significant decrease (27.1%) in LM at highest proportion of CP. The decrease in plant height in LM-based media mixtures could be attributed due to higher immobilization of available nutrients in the media mixtures that may be utilized by micro-organisms for decomposition of partially decomposed leaf tissue.

The mean plant spread was found significantly higher in FYM-based media mixtures irrespective of CP proportion compared to LM-based media mixtures. However, the differences in the mean plant spread was found in-significant with respect to varying proportions of soil:CP in each of the base media. Interaction between base media and media amendment yielded significant results recording a 20.5% increase in mean plant spread in FYM-based media mixtures with increase in CP proportion to 75%. However, the mean plant spread in LM-based media mixtures decreased (33.3%) significantly at highest proportion of CP.

Plants grown in BM comprising FYM recorded highest mean number of days for bud appearance as compared to LM but the differences were statistically nonsignificant. These findings were supported from study carried out by Mehmood *et al.* (2013) and Kiran *et al.* (2007) who recorded minimum number of days to flower bud formation in *Antirrhinum majus* L. and *Dahlia pinnata*, in media mixtures containing LM. The differences in the days to bud appearance was statistically significant with respect to media amendment. There was 6.5% increase in number of days for the buds to appear at highest proportion of CP compared to control (0% CP). Interaction of BM and MAs was found in-significant, however, the plants showed delay in days for the buds to appear with subsequent additions of CP (25%, 50%, 75%). This observation was contrary to the findings of Treder (2008) who reported early flowering in lilies and pelargonium, when these were grown in media containing CP. Delays in initiation of buds could be attributed due to higher retention of moisture at FC (6.81-8.14 cm^3cm^{-3}) in CP at higher proportions in each of the base media that result in delay in onset of reproductive stage or transition from vegetative to reproductive stage. Higher proportions of cocopeat amended media mixture favour better proliferation of roots and greater vegetative growth of plants due to gradual release of nutrients from CP as a result of slow mineralization. This ensures the release of nutrients for longer period resulting in delay in the number of days for the onset of reproductive phase. Moreover, higher moisture content in the CP amended media mixture ensures the greater solubility of nutrients readily available for uptake by the roots. Similar was the trend observed in mean number of days to colour show stage that were recorded higher in plants raised in BM comprising FYM and the difference was found significant as compared to the number of days taken by buds to show colour in the base media comprising LM. Plants raised in highest (75%) proportion of CP recorded a higher mean number of days (6.7 days) for buds to show colour compared to control and this difference was found statistically significant with respect to the media amendment. Interaction amongst the BM and MAs for days to colour break stage was found nonsignificant.

The mean flower number was statistically higher (25.0%) in base media comprising FYM as compared to LM. Tariq *et al.* (2012) reported that flower number had a positive correlation with P content in media. Greater number of flowers in media mixtures containing FYM could be attributed due to presence of adequate amount of available P (0.22-0.44%). Findings of Younis *et al*. (2007) reported that P nutrition enhances flowering and fruiting. Availability of P in the growing media could be due to more P exchangeable sites and enhanced activity of P-solubilizing and acid phosphatase producing organisms in media mixtures amended with CP (Scagel, 2003). Moreover, the plants were more responsive to available nutrients in FYM base media at higher proportions of CP due to better root proliferation and nutrient uptake. The mean number of flowers count was not consistent with respect to varying proportions of CP, however, the differences in the mean flower count were found in-significant. Interactive effect of BM and MAs for mean flower count was found significant. Addition of CP form 0-75% recorded an increase of 40.9% in flower number per plant in FYM-based media mixtures, however, the above trend showed 42.3% decrease in mean number of flowers in LM-based media mixtures at highest proportion of CP. Strojny and Nowak (2004) also reported profuse flowering in certain bedding plants raised in media mixtures rich in P content. The quality of flowers was found to be excellent in CP and this could be attributed due to high amount of K in CP (Handreck, 1993) that is important for bud initiation and subsequent flower development.

Duration of flowering was recorded significantly highest by 9.82% in plants raised in BM comprising LM compared to those raised in FYM. The duration of flowering was enhanced by 20.4% in LM-based media mixtures with increase in proportion of CP. Interactive effects among the BM and MAs for days to flowering duration was found nonsignificant. Chemical analysis of BM comprising FYM amended with varying proportions of CP revealed presence of adequate amounts of K to sustain healthy flowering of chrysanthemum both in terms of flower number and flowering duration.

Blending CP with suitable base media resulted in improved physical characteristics and water retention properties of media mixutres. The observations made in the experiment reveal that the physico-chemical properties of growing media were improved by mixing CP as an amendment with FYM as a base media. The CP being light in weight eased in mixing of the media mixtures and handling of flower pots. The higher total porosity of CP helped in maintaining balance between water retention and aeration for better uptake of nutrients in growing media contained in a limited volume of pot. Utilizing 75% CP as a media amendment in FYM proved to be the best media mixture for ideal growth and performance of potted chrysanthemum. At the same time it is environmentally safe and saves considerable amount of water applied in terms of increased number of days to irrigation due to improved water holding capacity of the media mixture.

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