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Standardization of container type, substrate and nutrition for potted plant production of China aster [*Callistephus chinensis* (L.) Ness.] var. Arka Archana

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ABSTRACT

A study was conducted at the ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru for three consecutive seasons during 2019-20, to standardize the container type, substrate combination and nutrition for potted plant production of China aster var. Arka Archana. The treatments comprised of two type of containers (plastic and coir), three substrates {Red soil + FYM + Sand (1:1:1 v/v), Arka Fermented cocopeat (AFC), AFC + Vermicompost (1:1 v/v)} and four nutrition concentration (160:30:180 ppm N:P: K, 128:24:144 ppm N:P: K, 96:18:108 ppm N:P: K and Jeevamrutha @ 3%) laid out in factorial completely randomized design with three replications. Plant height at flowering (33.12 cm), number of primary branches (12.4), plant spread (536.64 cm^2), number of flowers/plant (26.47), flower size (5.26 cm) and uptake of major, secondary and minor nutrients were maximum in the plants grown in 6" plastic pots using the substrate combination of soil +sand +FYM (1:1:1 v/v/v) along with the weekly application of nutrient solution of 96:18:108 ppm NPK/plant. This production protocol resulted in a dense canopy and highly floriferous potted plants. The benefit cost ratio of potted China aster production was 1.70. This technology can be adopted by the nurserymen for large-scale commercial potted plant production.

Keywords: Containers, substrate, China aster, nutrients, floriferousness, potted plant

INTRODUCTION

Potted plants are an important segment in commercial floriculture occupying the second place after cut flowers with the demand increasing over the years @ 20-25%. Global flower pots and planters' market is expected to reach USD 2,208.3 million by the end of 2024 from USD 1,869.6 million in 2018 (Anon., 2019). Rapid urbanization and shrinking land area for conventional gardening and emergence of many high-rise buildings in the city landscape has led to a huge market demand for flowering and foliage potted plants. Potted plants are displayed in outdoor spaces, in spaces that are the extension of the house and indoors to improve indoor air quality. It has been reported that potted-plants can reduce total volatile organic compound loads, a major class of indoor pollutants, by 75% (<100 ppb) and also CO and CO_2 contents.

Flowering potted plants like rose, chrysanthemum, aster, carnation, marigold etc. are in good demand for their aesthetic appeal beside other associated positive benefits. China aster [*Callistephus chinensis* (L.) Ness.], a member of the family Asteraceae, is a commercial flower crop of India grown mainly for loose and cut flower purpose over an area of 3500 ha in Karnataka, Tamil Nadu, Telangana, Andhra Pradesh, Maharashtra and West Bengal (Kumari *et al.*, 2018). This crop can also be grown in containers. China aster var. Arka Archana released from ICAR-IIHR, Bengaluru is an early bloomer, with spreading plant type, bearing semi double white flowers, the plant form and floriferous nature makes it a suitable candidate for potted plant production.

Most of the consumers prefer eco-friendly products considering the health benefits while using these in indoor closed spaces. Flowering potted plant production mainly relies on the selection of appropriate containers, potting media and optimum nutrition, which tends to influence the crop canopy and floriferousness. Alternate containers like coir pots are gaining popularity with certain section of consumers. An ideal potting substrate must possess unique physical and chemical characteristics favoring maximum water retention between irrigations while being well drained in order to avoid drought and root asphyxia (Caron and Nkongolo, 1999). Application of balanced nutrients to the potted plants, its solubility, availability, frequency of application is some of the factors that require standardization. The present study was undertaken to determine the effects of type of containers, substrate and nutrient levels on quality potted plant production of China aster var. Arka Archana.

MATERIALS AND METHODS

The study on potted plants of China aster var. Arka Archana was done at the ICAR - Indian Institute of Horticultural Research, Bengaluru, Karnataka, India. The pot plant experiment was conducted for a period of three seasons, i.e., February – May, 2019, July – October, 2019 and November 2019 – February, 2020 (Fig. 1). The pots were kept under open condition with full sunlight. Physical and chemical properties of initial and post-harvest media composition were analysed. The treatment details are as follows; Factor A: Type of pots (P_1: 6" plastic pot; P_2: 6" coir pot); Factor B: Substrate (S_1: red soil + FYM + sand (1:1:1 v/v), S_2: Arka Fermented cocopeat (AFC), S_3: AFC + Vermicompost (1:1 v/v)}; Factor C: Nutrition concentration (N_1- 160:30:180 ppm, N_2- 128:24:144 ppm, N_3 - 96:18:108 ppm N:P:K; N_4 - Jeevamrutha @ 3% (organic source). For treatments N_1, N_2 and N_3, secondary and micronutrients applications were kept unchanged. Nutrient solution application was scheduled at weekly intervals @ 50 ml / pot. The experiment was conducted in factorial CRD design with three replications and ten pots per replication. One month old seedlings at 4-6 leaves stage were transplanted in the centre of each pot @ one seedling/pot and watered. Thereafter regular need-based watering was done, depending on the media and season. The texture and porosity of the growing medium were important considerations in deciding the frequency of irrigation. Pots containing substrate with cocopeat, cocopeat + vermicompost retained moisture for longer period compared to soil + sand + FYM media. Pinching was done one month after transplanting. Prophylactic sprays of plant protection chemicals ensured no severe infestation of pest and diseases during the period of experimentation.

The substrates Arka Fermented Cocopeat (AFC), soil and FYM were characterized as per the standard procedures. Soil physical and chemical properties were estimated by following standard procedures (Jackson, 1973). For nutrient uptake studies, nitrogen (N) contents in the plant samples were analyzed after mineralization with sulfuric acid by Kjeldahl method (Jackson, 1973). Phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) were estimated digesting with a triacid mixture (9:4:1 HNO_3: $HClO_4$: H_2SO_4) as described by Jackson (1973).

Observations were recorded at flowering stage on the vegetative and flowering parameters *viz*., plant height (cm), number of primary branches, number of secondary branches, plant spread (cm^2), leaf area (cm^2), internodal length, number of flowers $plant^{-1}$, flower diameter (cm) and duration of flowering. Economic analysis of potted plant production of China aster was done considering the market price ranging from Rs. 45-70 per pot, depending upon the type of pot (plastic or coir), appearance and display life for computing gross returns from economic produce. Pooled analysis of the data for three seasons on different growth and yield parameters was done using statistical software WASP 2.0 (Web Agri Stat Package, ICAR-Central Coastal Agricultural Research Institute, Goa).

RESULTS AND DISCUSSION

Vegetative parameters: Plant height was recorded at the time of flowering varied significantly for the factors container type, substrate and nutrient doses (Table 1) and for their interaction effect (Table 2). Maximum plant height was observed in plastic pots, P_1 (26.32 cm) whereas; it was minimum in coir pots (P_2). Among different types of substrates used, maximum plant height (31.22 cm) was observed in S_1 (Red soil + sand + FYM), followed by S_3 (AFC + vermicompost) and minimum (21.30 cm) was recorded in S_2 - AFC alone. Among different nutrient levels used, maximum plant height was observed in application of 96:18:108 ppm of N:P:K - N_3 (26.45cm) and minimum was in Jeevamrutha - N_4 (23.33 cm). Among the interaction effects, plants grown in plastic pots using red soil + FYM + sand media with the application of 96:18:108 ppm NPK

Table 1 : Influence of type of pot, substrate and nutrients on growth and yield parameters of China aster var. Arka Archana potted plant at flowering (pooled mean of three seasons)

Treatment	Plant Height (cm)	No. of primary branches	No. of secondary branches	Av. plant spread area (cm^2)	Internodal length (cm)	Leaf area (cm^2)	Flower size (cm)	No. of flowers/ pt	Duration of flowering (days)
Type of pots									
P_1 - Plastic pot	26.32	6.96	2.96	251.61	2.58	15.59	4.68	16.24	32.40
P_2 - Coir pot	25.26	5.82	2.54	238.42	2.22	14.06	4.54	13.40	29.08
SEm±	0.40	0.20	0.12	8.53	0.1	0.39	0.77	0.26	0.62
CD@5%	1.05	0.52	0.31	20.90	NS	0.95	0.19	0.68	1.50
Type of substrate									
S_1 - Red soil +FYM + Sand (1:1:1 v/v)	31.22	8.37	3.10	295.78	2.46	15.80	4.95	17.46	32.75
S_2 - Arka Fermented cocopeat (AFC)	21.30	4.49	2.47	202.56	2.11	14.09	4.29	11.57	29.05
S_3 - AFC + Vermicompost (1:1 v/v)	24.84	6.30	2.67	236.72	2.63	14.60	4.58	15.44	30.41
SEm±	0.50	0.25	0.25	9.84	0.16	0.26	0.10	0.32	0.71
CD@5%	1.29	0.64	0.66	25.59	NS	0.67	0.24	0.83	1.73
Nutrient concentration									
N_1 - 160:30:180 ppm	24.07	6.21	2.67	236.12	2.31	14.45	4.58	14.88	30.07
N_2 - 128:24:144 ppm	26.77	6.30	2.64	266.76	2.2	14.94	4.65	15.03	30.22
N_3 - 96:18:108 ppm	26.45	6.84	2.87	246.55	2.79	15.38	4.72	15.26	31.92
N_4 - Jeevamrutha @ 3% weekly drenching	25.86	6.21	2.80	230.65	2.31	14.54	4.49	14.13	30.75
SEm±	0.57	0.28	0.29	11.37	0.19	0.22	0.12	0.37	0.79
CD@5%	1.49	0.74	0.76	29.55	NS	0.57	0.28	0.96	1.93

($P_1S_1N_3$) recorded maximum plant height (37.11 cm) and it was minimum in plants grown in plastic pot using red soil + FYM + sand media with the application of Jeevamrutha drenching@ 3% ($P_1S_1N_4$) and pot using AFC media with the application of nutrient combination of 160:30:180 ($P_1S_2N_1$).

Number of primary and secondary branches was significant for individual factors (Table 1) and their interaction (Table 2). Maximum number of primary and secondary branches was observed in plastic pots, P_1 (6.96 and 2.92, respectively), red soil + FYM + sand medium - S_1 (8.37 and 3.10, respectively) and nutrient combination of 96:18:108 ppm of N:P:K – N_3 (6.84 and 2.87, respectively). Among the interaction effect, significantly highest number of primary branches was obtained using plastic pots using red soil + FYM + sand media with the application of nutrient combination of 160:30:180 ppm of N:P:K $P_1S_1N_1$ (12.73). The number of secondary branches was found maximum (3.8) in plastic pots, red soil + FYM + sand medium with the application of 96:18:108 ppm of N:P:K ($P_1S_1N_3$).

Plant spread area was significant for individual factors (Table 1) and their interaction (Table 2). Maximum plant spread was recorded in plastic pots - P_1 (251.61 cm^2) substrate containing red soil + sand + FYM - S_1 (295.78 cm^2) and supplied with nutrients, 96:18:108 ppm of N: P: K - N_3 (266.76 cm^2). Among the interaction effect, maximum plant spread was in plastic pots, red soil + FYM + sand medium with the application of 96:18:108 ppm of N:P:K $P_1S_1N_3$ (380.05 cm^2). Internodal length of pooled mean showed non-significant differences for all the three factors and their interaction (Table 1 & Fig 3). Leaf area was found to be significantly different among the treatment combinations (Table 3). Maximum leaf area was observed in P_1 (15.59 cm^2). In substrate combination, red soil + FYM + sand media (S_1) reported maximum leaf area of 15.85 cm^2. Application of nutrient 96:18:108 ppm of N:P:K (N_3) resulted in maximum leaf area of 15.38 cm^2. Among interaction effect, $P_1S_1N_3$ recorded maximum leaf area of 16.79 cm^2 (Table 1 and 3).

In potted plant production plant growth and appearance plays an important role, not only to increase its marketing value by improving its appearance but also to improve the floriferousness. In this study, plant growth parameters like plant height, number of primary and secondary branches and plant spread was found ideal in plants grown in plastic pots using substrate containing red soil + sand + FYM along with the application of the nutrients, 96:18:108 ppm of N: P: K. This increment of growth parameters could be attributed to the great input of nutrients provided by the media combination and balanced fertilizer dose which supplied the required quantity of major, secondary and micronutrients. The importance of potting media and nutrient application for ornamental plant production has been highlighted by Jayasinghe (2012) and our findings are also in line with his findings.

Floral parameters: Number of flowers per plant was found to be significant for all the three factors (Table 1) and their interaction (Table 3). Among factor A, maximum number of flowers per plant for pooled mean of three harvests was observed in plastic pots (P_1) (16.24) compared to coir pots (13.4). Among different substrates used, maximum number of flowers was observed in S_1 (17.46), followed by S_3 (15.44) and minimum was in S_2 (11.57). Among nutrients, application of 96:18:108 ppm of N:P:K (N_3) recorded maximum number of flowers (15.26). Among interaction treatment $P_1S_1N_3$ recorded maximum number of flowers (21.85).

Flower size is an important aspect of potted plant production. Bigger the bloom indicates better display quality and attractiveness. Flower size was significant for two individual factors (Table 1) and interaction of three factors (Table 3). Maximum flower size was observed in plastic pots (4.68 cm) grown in red soil + FYM + sand media (4.95 cm) with the application of 96:18:108 N:P:K - N_3 (4.72 cm). Among interaction effect, treatment combination of plastic pot+ red soil + FYM + sand along with application of 96:18:108 ($P_1S_1N_3$) recorded maximum flower size of 5.26 cm.

Flowering duration plays an important role in analyzing the display life of the pot plant. In the present study, the flowering duration showed significant differences for individual factors and their interaction (Table 1 & 3). Flowering duration was maximum in plants grown in plastic pots (32.4 days), consist of red soil + FYM + sand media (32.75 days) and with the application of nutrient of 96:18:108 ppm of N:P:K (31.92 days). Among interaction effect, interaction of all these factors (plastic pots, red soil + FYM + sand media and nutrient of 96:18:108 ppm

Fig. 1 : General view of China aster var. Arka Archana potted plant experiment

Fig. 2 : Best performing treatments of the China aster pot plant experiment

Table 2 : Interaction of type of pot, substrate and nutrients on plant growth parameters in pot plant of China aster var. Arka Archana (pooled mean of for three seasons)

Treatment	Plant height (cm)						Number of primary branches						No. of secondary branches						Plant spread (cm²)					
	P_1			P_2			P_1			P_2			P_1			P_2			P_1			P_2		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
N_1	27.23	18.22	27.35	26.93	20.45	24.27	8.46	4.12	6.77	7.62	4.51	5.77	2.82	2.20	2.98	2.49	2.33	3.17	307.73	168.44	249.98	250.74	155.62	269.04
N_2	32.55	22.73	25.10	31.96	21.09	25.30	8.22	4.73	6.48	7.29	4.41	6.69	3.18	2.44	2.54	2.60	2.43	2.66	322.82	206.61	221.04	263.74	216.65	248.45
N_3	37.11	23.03	23.24	29.49	22.47	25.25	12.73	4.46	6.97	6.38	5.00	5.52	3.80	3.21	3.07	2.58	1.70	2.85	380.05	240.79	209.83	286.23	242.70	256.07
N_4	35.20	20.75	23.26	29.29	21.67	24.97	9.69	4.76	6.11	6.60	3.96	6.11	3.36	2.87	2.99	2.71	2.57	2.33	289.72	224.14	198.23	248.60	162.43	260.78
	SeM±			CD(P= 0.05)			SeM±			CD(P= 0.05)			SeM±			CD(P= 0.05)			SeM±			CD(P= 0.05)		
N	0.43			1.05			0.21			0.52			0.22			0.54			8.50			20.90		
P	0.52			1.29			0.26			0.64			0.27			0.66			10.40			25.59		
S	0.61			1.49			0.30			0.74			0.47			NS			12.01			29.55		
P X S	0.74			1.82			0.37			0.90			0.38			0.93			14.72			36.20		
P X N	0.85			2.10			0.42			1.04			0.51			NS			19.8			NS		
S X N	1.04			2.57			0.52			1.27			0.54			1.32			20.81			51.19		
P X S X N	1.48			3.64			0.73			1.80			0.76			1.86			29.43			72.39		

Factor A: Type of pots (P_1: Plastic pot; P_2: Coir pots); Factor B: Substrate (S_1: Red soil + FYM + Sand (1:1:1 v/v), S_2: Arka Fermented cocopeat (AFC), S_3: AFC + Vermicompost (1:1 v/v)}; Factor C: Nutrition concentration (ppm) (N_1- 160:30:180, N_2- 128:24:144, N_3 - 96:18:108 N:P:K; N_4 - Organic source (Jeevamrutha @ 3% weekly drenching)

Table 3 : Interaction of type of pot, substrate and nutrients on yield and quality parameters in pot plant of China aster var. Arka Archana (pooled mean of for three seasons)

Treatment	Leaf area (cm²)						No. of flowers/plant						Flower size (cm)						Duration of flowering (days)					
	P_1			P_2			P_1			P_2			P_1			P_2			P_1			P_2		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
N1	16.71	16.73	14.56	15.04	14.53	16.60	17.03	12.17	17.53	17.02	11.95	13.56	4.33	4.85	5.27	5.18	3.75	4.07	34.8	29.5	32.3	30.1	26.3	27.4
N2	16.15	15.51	14.48	11.99	13.84	14.53	17.43	15.28	15.81	16.50	11.07	14.82	4.46	5.19	5.02	4.96	3.84	4.62	33.2	30.2	31.2	30.7	27.6	28.4
N3	16.79	16.72	13.16	12.49	13.80	15.00	21.85	12.29	13.41	16.62	13.28	13.35	5.26	4.56	4.10	5.08	3.93	5.14	35.9	31.5	34	32.4	28.2	29.5
N4	16.90	14.32	15.11	15.07	12.52	13.32	15.47	11.82	12.98	17.91	13.01	13.57	5.08	4.38	3.41	5.06	3.85	4.75	33.7	30.7	31.8	31.2	28.4	28.7
	SeM±			CD(P= 0.05)			SeM±			CD(P= 0.05)			SeM±			CD(P= 0.05)			SeM±			CD(P= 0.05)		
N	0.38			0.95			0.28			0.68			0.08			0.19			0.62			1.50		
P	0.27			0.67			0.34			0.83			0.10			0.24			0.71			1.73		
S	0.23			0.57			0.39			0.96			0.11			0.28			0.79			1.93		
P X S	0.38			NS			0.48			1.18			0.14			0.34			0.93			2.26		
P X N	0.45			1.12			0.55			1.36			0.16			0.39			1.05			2.55		
S X N	1.09			2.74			0.68			1.67			0.20			0.48			1.24			3.02		
P X S X N	1.23			3.08			0.96			2.36			0.28			0.67			1.68			4.08		

Factor A: Type of pots (P_1: Plastic pot; P_2: Coir pots); Factor B: Substrate (S_1: Red soil + FYM + Sand (1:1:1 v/v), S_2: Arka Fermented cocopeat (AFC), S_3: AFC + Vermicompost (1:1 v/v)}; Factor C: Nutrition concentration (ppm) (N_1- 160:30:180, N_2- 128:24:144, N_3 - 96:18:108 N:P:K; N_4 - Organic source (Jeevamrutha @ 3% weekly drenching) of N:P:K) recorded maximum display life of 35.90 days. It was minimum in plants grown in coir pots, AFC media with the application of 160:30:180 ppm of N:P:K (26.30 days). In the present study, plant growth parameters (plant height, number of primary branches, plant spread) at flowering and yield parameters (number of flowers/plants, flower size) and uptake of nutrients were maximum in the plants grown in 6" plastic pots compared to coir pots of the same size. The coir pots maintained the shape for 3-4 months, thereafter started degrading. Similar observations were made in Poinsettia potted plants grown in containers made of 100% biodegradable polyester for breakage problems during the handling of the marketing phase (Castronuovo, 2015). The coir pots required frequent irrigation compared to plastic pots which was also reported by Evans *et al*. (2015) in vinca (*Catharanthus roseus*). Beeks and Evans (2013) also analyzed the behavior of nine bio containers in comparison with a traditional petroleum-based plastic containers for the production of cyclamen (*Cyclamen persicum* L.) cv. 'Rainer Purple' and pointed out those most plantable containers are not suitable for this purpose.

Analysis of substrate composition: The substrate AFC had the following characteristics: bulk density 0.16 Mg m^{-3}; porosity 67.8%; pH 6.75; electrical conductivity 0.5 dSm^{-1}; total carbon 36.1%; total N 0.98%; total P 0.07%; total K 2.20% and Na 0.35%. The average concentration of macronutrients was estimated at 0.58% N, 0.26% P_2O_5 and 0.60% K_2O in FYM. Physical and chemical characteristics of the soil were: bulk density 1.28 Mg m^{-3}; porosity 51.3%; pH 6.97, electrical conductivity 0.26 dSm^{-1}; organic carbon 7.8 g kg^{-1}; available N 0.13 g kg^{-1}; 18 mg kg^{-1} Olsen's P, ammonium acetate (CH_3COONH_4) extractable nutrients as follow: 0.90 g Ca kg^{-1}, 0.174 g Mg kg^{-1} and 0.15 g K kg^{-1} and DTPA extractable micronutrients as follow: 10.3 mg kg^{-1} Fe, 5.70 mg kg^{-1} Mn, 2.24 mg kg^{-1} Cu and 1.35 mg kg^{-1} Zn. Plant production in growth media includes materials that contain soil or soilless media (Savvas *et al*., 2013). Plant faces two basic challenges for root growth in the containerized plant production system. The first one is the very shallow root growth area in the container environment which quickly becomes saturated after watering as compared to normal soil profile having limitless area for drainage. The second one is the limited water storage capacity between the irrigation intervals due to small volume of the container (Bunt, 1988). The physical structure must maintain equilibrium between air and water over the entire crop cycle, which is few months for annuals to prolonged time for perennials. The potting substrate physical properties are usually assessed by its particle size and shape, texture and physical organization (Bilderback *et al*., 2005). Selection of an ideal substrate, either soil or soilless is one of the important keys for success of potted plant production. Our studies have revealed that the substrate combination of soil + sand + FYM (1:1:1 v/v) have recorded compact plant growth, yield and quality parameters compared to AFC + vermicompost and AFC alone. Addition of organic matter as compost or manure (green manure, farm yard manure, poultry manure) is a common practice for growing potted plants. In addition to supplying plant nutrients, it provides a favourable physical and biological environment for plant roots in the growth medium (Kumar and Goh, 2000). Therefore, an ideal potting substrate must possess unique physical and chemical characteristics favoring maximum water retention between irrigation while being well drained in order to avoid drought and root asphyxia (Nkongolo and Carol, 2006). Thus, the potting substrate is a pivotal advancement in plant production system providing grower with the full control over air, water and nutrients delivery as well as pathogen free environment to plant roots (Raviv *et al*., 2002). On a commercial scale, there is a need of bulk quantity raw constituents for the production of soilless growing media (Carlile *et al*., 2015). The growing substrate should also be economical and practical enough to be used for commercial purposes.

Nutrient uptake: The plant nutrient uptake as influenced by pot types, substrates and nutrient levels are given in Figure 4. Nutrient uptake was found to be non-significant for type of pots. Among the substrate combinations, red soil + sand + FYM recorded highest plant nutrient uptake for most of the nutrients {N (0.19 g/pt), Ca (0.15 g/pt), Mg (0.06 g/pt), Fe (4.45 mg/pt), Mn (0.67 mg/pt) and Zn (0.55 mg/pt)} followed by AFC + vermicompost and all these parameters were found minimum in pots containing AFC alone. With respect to nutrient levels, the highest nutrient uptake {N (0.21 g/pt), K (0.35 g/pt), Ca (0.14 g/pt), Mg (0.06 g/pt), S (0.01 g/pt), Fe (4.04 mg/pt), Mn (0.68 mg/pt), Zn (0.59 mg/pt), Cu (0.63 mg/pt)} was recorded with application of 96,

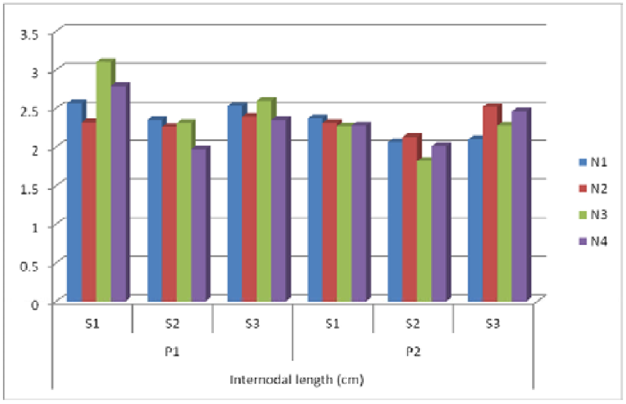

Fig. 3 : Interaction effect of type of pots, substrate and media combination on internodal length of China aster var. Arka Archana

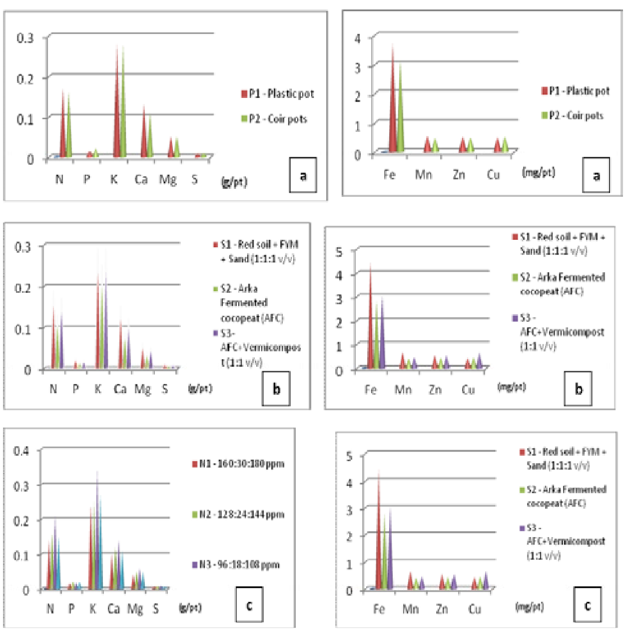

Fig. 4 : Nutrient uptake by China aster Var. arka Archana plants under pot experiment

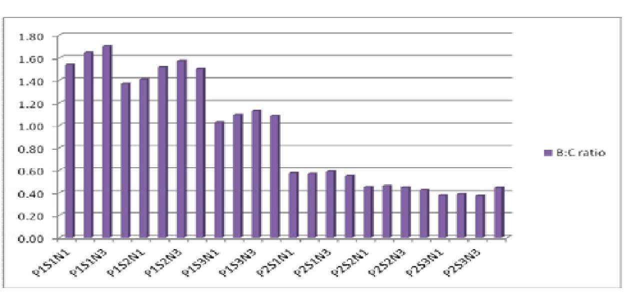

Fig. 5 : B:C ratio of different treatments of China aster Var. Arka Archana pot experiment

Factor A: Type of pots (P_1: Plastic pot; P_2: Coir pots); Factor B: Substrate (S_1: Red soil + FYM + Sand (1:1:1 v/v), S_2: Arka Fermented cocopeat (AFC), S_3: AFC + Vermicompost (1:1 v/v)}; Factor C: Nutrition concentration (ppm) (N_1- 160:30:180, N_2- 128:24:144, N_3 - 96:18:108 N:P:K; N_4 - Organic source (Jeevamrutha @ 3% weekly drenching)

18 and 108 ppm of N:P:K (N_3). This was followed by N_2 (128:24:144 ppm of N:P:K) and found to be on par with Jeevamrutha @ 3% weekly drenching (N_4). The lowest nutrient uptake was recorded with application of higher levels of nutrient application (N_1- 160:30:180 ppm of N: P:K). Plant nutrition plays a pivotal role especially when it is grown in container. In this experiment among three levels of nutrient application and one organic combination - jeevamrutha, weekly application of lower concentrations of nutrient solution of 96:18:108 ppm N:P:K/plant (Arka Sasya Poshak Ras) has given better plant growth, flower yield and quality parameters. Similar studies on *Adenum obesum* 'Red' under low nutrient supply was found to relocate more biomass into roots (McBride, 2014). However, *Tabernaemontana pachysiphon* Staph treated with three levels of Osmocote, two water regimes, and two light intensities indicated that increasing nutrient supply had a positive effect on growth (Hoft *et al.*, 1996). Mandevilla Vogue varieties were shown to be moderate feeders, responding best to use of a balanced fertilizer at a rate of 100 to 200 mg L^{-1} and it was recommended that a low to medium rate of a standard slow- release fertilizer should be added at planting (Mart, 2012). *Plumeria rubra* grown in pure silica sand in 4-L containers were treated with a low and high nutrient level (2.4 g and 24.0 g, respectively, of 14N–14P–14K of Osmocote) revealed that more biomass was produced under high nutrient supply, whereas more biomass was allocated to the roots in low nutrient supply (Huante *et al.*, 1995). Vinca (*Catharanthus roseus* L.) seedlings benefitted from high concentrations of N (up to 32 mM) in the fertilizer, whereas only low concentrations of phosphorus and potassium (0.25 mM) were needed (Van Iersel *et al.*, 1999). The ideal potting substrate must also deliver an appropriate environment for proper plant nutrient availability. Nutrient availability is very much dependent on the chemical properties including pH, cation exchange capacity, electrical conductivity of the substrate etc.

Economic analysis: Economic indicators have been worked out considering the cost of inputs (pots, substrate and nutrients), labour and maintenance cost (Fig 5). The three-season study suggested that pot plant production of China aster var. Arka Archana was profitable in plants grown in plastic pots using red soil + FYM + sand media with the application of

96:18:108 ppm of N:P:K ($P_1S_1N_3$) with a B:C ratio of 1.70. This might be due to the lower cost of production and better display life of the potted plant grown in this treatment. In general plants grown in plastic pots recorded better B:C ratio in the range of 1.02 to 1.70, whereas, coir pots due to higher cost of pots recorded lower B:C ratio range of 0.37 to 0.59. An alternative to the use of plastics in potted plant production could be the use of biodegradable pots instead of plastic pots (Sartore *et al*., 2013). However, the technical performance and suitability for agricultural applications, of these biodegradable materials, that can be easily degraded by naturally occurring microorganisms must be ensured (Lucas *et al*., 2008). The cost of bio pots is too high than traditional ones to make them utilizable by growers on large scale (Brumfield *et al*., 2015) and it is about twice the cost the traditional ones according to Minuto *et al*. (2008). This aspect is even more important for annual crops like potted China aster wherein the production costs should be considered as it is a short duration crop.

CONCLUSION

From the results of the study, it is evident that in pot plant production of China aster var. Arka Archana, plant growth parameters like plant height (33.12 cm), number of primary branches (12.4), plant spread (536.64 cm^2) at flowering and yield parameters like number of flowers/plant (26.47), flower size (5.26 cm) and uptake of nutrients were maximum in the plants grown in 6" plastic pots by using the substrate combination of red soil + sand + FYM (1:1:1 v/v) along with the weekly application of nutrient solution of 96:18:108 ppm NPK/plant (Arka Sasya Poshak Ras). The same treatment is profitable with the highest B:C ratio of 1.70. This technology can be adopted for large-scale commercial potted plant crop production as flowering potted plants are a way to bring in a visually pleasing effect, soften the hard lines of the living spaces that give health benefits.

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