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Physiological Response of China Aster [*Callistephus chinensis* (L.) Ness] under Shade Net Conditions

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The present investigation was carried out during the year 2017-18 at College of Horticulture, Dr. Y.S.R Horticultural University, Anantharajupeta, Y.S.R. Kadapa Dist. of Andhra Pradesh. The experiment consisted of 7 China aster genotypes, laid out in randomized block design with four replications under 50 per cent shade net condition. Significant variations were observed among different genotypes with respect to physiological and biochemical traits. Among the genotypes, Arka Archana recorded highest leaf area plant^{-1} (204.58 cm^2, 1297.89 cm^2 and 2689.49 cm^2), biomass (3.50 g plant^{-1}, 16.00 g plant^{-1} and 33.00 g plant^{-1}) and LAI (0.228, 1.443 and 2.990) at 30, 60 and 90 DAT. Arka Archana also recorded maximum AGR (0.425 g day^{-1}) and SPAD value (44.26) at 30-60 DAT interval, LAD (25.04, 66.46 days) at 30-60 and 60-90 DAT interval. While highest LAR (100.37cm^2 g^{-1}, 138.13cm^2 g^{-1} at 60, 90 DAT) and protein content (40.50 µg g^{-1}, 133.00 µg g^{-1} in leaves and flowers) was observed in Arka Kamini. However, maximum anthocyanin content of 207.40 mg 100 g^{-1} was recorded in Local violet and highest AGR at 60-90 DAT interval (0.790 g day^{-1}), protein content in seeds (652.00 µg g^{-1}) was registered in genotype Arka Aadya. The genotype Arka Shashank recorded the highest leaf area ratio at 30 DAT (65.05 cm^2 g^{-1}).

Key words: China aster, Genotypes, Physiological attributes, Shade net house.

China aster [*Callistephus chinensis* (L.) Ness] belongs to one of the largest families of flowering plants, Asteraceae possessing chromosome number 2n=18. It is one of the most important annual flower crops grown in most parts of the world. Among annuals, it is claimed to rank third for popularity, after chrysanthemum and marigold (Sheela, 2008). China aster is commercially grown by marginal and small farmers in Karnataka, Tamil Nadu, Telangana, Andhra Pradesh, Maharastra and West Bengal (Kumari *et al.,* 2017). China aster can be grown throughout the year under Bengaluru conditions. In Andhra Pradesh, it has a great demand in local market as cut flower and potted plants. Consumers were not satisfied due to lack of selection of varieties as well as improper use of agro-techniques. Though many genotypes of China aster can be grown in any agro-climatic region, all of them are not suited for cut flower purpose, garden display and exhibition purpose. So, there is a need to evaluate hybrids and varieties in any particular agro-climatic region.

Anantharajupeta falling in Southern region of Andhra Pradesh is a potential region with rich crop diversity. It is endowed with mild tropical climate and red loamy soils. Several reports of good performance by modern cut flowers are available from the location. To meet the growing demand for cut flowers in the fast growing areas of Rayalaseema region of Andhra Pradesh, introduction and popularization of modern flowers is needed.

Increased flower quantity and quality with perfection in the form of plants are important objectives to be reckoned in commercial flower production. Although, there are sufficient number of cultivars under cultivation but their performance are region specific and varies from place to place, information on best China aster cultivar for loose flower production and cut flower production is lacking under the tropical conditions of semi-arid zone of Southern Andhra Pradesh. Hence, the present investigation was designed to determine the best suitable China aster cultivars for quality cut flower and loose flower production which is important to select cultivars for high market prices.

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Material and Methods

The present investigation on China aster genotypes was conducted during *Rabi* season of 2017-2018 under shade net condition at College of Horticulture, Anantharajupeta, Y.S.R Kadapa Dist. The experiment was laid-out in Randomized Block Design, replicated quadruple. The trail consist of seven genotypes *viz.,* G_1- Arka Aadya, G_2- Arka Shashank, G_3- Arka Archana, G_4- Arka Poornima, G_5- Arka Kamini, G_6- Local pink and G_7- Local violet (check). The seeds of five genotypes was collected from Indian Institute of Horticultural Research (IIHR), Bengaluru, Local Pink from Agricultural Research Institue (ARI), Rajendranagar, Hyderabad and Local Violet (check) from Mydukur area of Y.S.R Kadapa Dist. Andhra Pradesh. Ploughing and digging of the land was done and brought to fine tilth under shade net and environment conditions presented in Table 1. All weeds were completely removed from the field. All the stubbles of previous crop were removed from the field and burnt. The required numbers of plots (28) were prepared of size (1.80 m × 1.80 m) with bunds of 60 cm between plots. The length of experimental field was 12.60 m and width was 9.00 m. Well decomposed farm yard manure was applied uniformly to all the experimental plots at 25 t ha^{-1} and mixed well. Nitrogen (180 kg ha^{-1}), phosphorus (120 kg ha^{-1}) and potassium (60 kg ha^{-1}) (Dr.Y.S.R.H.U, Andhra Pradesh recommendation) were applied. The entire quantities of phosphorus, potash and 50 per cent of nitrogen were applied as basal dose and remaining 50 per cent nitrogen was applied as a top dressing at forty days after transplanting in all the experimental plots. The seedlings required were obtained from seven raised nursery beds of size 3.00 m x 1.00 m.

The beds were first drenched with captan (0.2%) and seeds were sown thinly and uniformly in lines and covered with a mixture of well rotten FYM and top soil. Seeds of different varieties were also treated with captan (2 g / kg seeds) for five minutes and then sown in lines. The nursery beds were watered twice daily, once in the morning and again during evening for the first 10 days and thereafter once daily for the remaining period. Hand weeding was done as and when weeds were noticed. Forty-five-days old healthy seedlings of uniform growth were used for transplanting. Transplanting was done in the evening at the rate of one seedling per hill and light irrigation was given immediately after planting. Necessary plant protection measures were followed to prevent insect pest incidence. At initial stages of growth, chlorpyriphos @ 2-3 ml $litre^{-1}$ of water was sprayed to control *Spodoptera litura* and disease incidence was not noticed during period of investigation.

Five plants were selected in each plot at random and were labeled properly for recording observations. The data on physiological and biochemical observations were recorded with the procedures adopted in Leaf area Index (LAI) (Williams, 1946), Leaf area Duration (LAD) (Escalante and Kohashi, 1993), Absolute Growth Rate (AGR) (Hunt, 1978), anthocyanin content (Shivashankar *et al*., 2010) and protein content (Lowry *et al*., 1951). The data were analyzed using the procedure outlined by Panse and Sukhatme (1978).

Results and Discussion

Leaf area

A perusal of data in the Table 2 indicated that the leaf area $plant^{-1}$ varied significantly due to the influence of genotypes. Among multiple genotypes, leaf area $plant^{-1}$ was maximum (204.58, 1297.89, 2689.49 cm^2) in genotype Arka Archana at 30, 60 and 90 DAT. Leaf area (or) photosynthetic area fairly gives a good idea of the photosynthetic capacity of the plant. The leaf area $plant^{-1}$ increased significantly during course of time. The increase in leaf area can be attributed to increase in leaf number. This was due to the increase in number of leaves as the number of branches increased thus producing more leaf area $plant^{-1}$. Since genotypes varied for their number of leaves, accordingly their leaf area $plant^{-1}$ also varied. The results are well in accordance with the reports made by Tirakannanavar *et al*. (2015) in China aster and Priyanka *et al.* (2017) in Crossandra.

Table 1. Monthly mean temperature, relative humidity and light intensity

Month	Temperature (^{0}C)		Relative humidity (%)		Rainfall (mm)	Light intensity (lux)
	Max.	Min.	8.00 am	2.00 pm		
January, 2018	29.5	15.1	72.8	56.7	0.0	28921
February,2018	31.3	16.9	70.9	54.7	3.0	30896
March, 2018	34.3	20.0	68.8	52.7	25.4	32921
April, 2018	36.4	22.1	66.4	51.1	24.0	34397
May,2018	38.6	24.3	63.6	49.9	0.0	36021

Biomass

The data presented in Table 2 showed significant influence on biomass $plant^{-1}$ in all genotypes. Maximum biomass of (3.50, 16.00, 33.00 g $plant^{-1}$) at 30, 60 and 90 DAT was recorded in Arka Archana. The increase in leaf area $plant^{-1}$ increases the total biomass content of the plant and effective photosynthetic area on the plant which produces more assimilates in the plant from source (leaves) to sink (flowers). Thus, the yielhhd of flowers also increases. It was observed from earlier results that, plant height, number of leaves, branches $plant^{-1}$, plant spread and leaf area $plant^{-1}$ recorded were highest in genotype Arka Archana which might have resulted in increased biomass production in the genotype. These results are in tune with the findings of Priyanka *et al.* (2017) in Crossandra genotypes.

Leaf area index

Significant response of China aster genotypes was observed for leaf area index (Table 2). Among the genotypes, Arka Archana had maximum leaf area index (0.228, 1.443, and 2.990) at different growth stages. LAI measures the light interception of leaves of plants. More LAI values give more light interception. Thus, higher LAI values give more photosynthesis, therefore producing more assimilates. The increase in leaf area index might be due to increase in number of branches which results in production of more number of leaves and leaf area $plant^{-1}$. The leaf area $plant^{-1}$ recorded was maximum in genotype Arka Archana (Table 2) which resulted for maximum leaf area index. Increase in leaf area increases the absorption of maximum amount of solar radiation and hence the total dry matter accumulation was also high. The variation in leaf area index among the genotypes

Table 2. Response of China aster genotypes on leaf area, biomass and leaf area index

Genotypes	Leaf area plant^{-1} (cm^2)			Bio mass (g plant^{-1})			Leaf area index		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Arka Aadya	140.27	488.37	2522.81	2.70	9.25	32.75	0.155	0.543	2.800
Arka Shashank	198.94	839.09	1622.50	3.10	12.50	23.00	0.223	0.933	1.800
Arka Archana	204.58	1297.89	2689.49	3.50	16.00	33.00	0.228	1.443	2.990
Arka Poornima	99.63	478.58	1387.86	3.20	10.50	22.00	0.113	0.530	1.543
Arka Kamini	97.01	700.48	2654.89	2.40	7.50	19.25	0.108	0.778	2.948
Local Pink	151.77	651.05	1687.97	2.39	10.25	18.00	0.170	0.725	1.875
Local Violet (check)	57.65	263.02	823.86	2.15	9.75	20.00	0.060	0.293	0.915
SEM ±	5.02	8.20	53.09	0.13	0.88	1.26	0.006	0.009	0.059
CD (*P*= 0.05)	15.01	24.54	158.96	0.38	2.62	3.76	0.017	0.027	0.177

might be due to differences in leaf area of plants significantly. The above results are corroborated with the findings of Tirakannanavar *et al.* (2015) in China aster.

Leaf area ratio

The data depicting the leaf area ratio in seven genotypes are presented in Table 3. The genotype Arka Shashank recorded the highest leaf area ratio (65.05 cm^2 g^{-1}) at 30 days after transplanting. At 60 and 90 days after transplanting, the genotype Arka Kamini had maximum leaf area ratio (100.37, 138.13 cm^2 g^{-1}). The value of leaf area ratio differed significantly among China aster genotypes at various growth stages studied. This variation was due to the variation in net assimilation by various genotypes during all growth stages as well as the favorable environmental conditions in shade net house (Table 1). Parallel results are also reported by the findings of Kumar *et al.* (2013) in rice.

Table 3. Response of China aster genotypes on leaf area ratio, leaf area duration), absolute growth rate and chlorophyll content

Genotypes	Leaf area ratio (cm^2 g^{-1})			Leaf area duration (days)		Absolute growth rate (g day^{-1})		Chlorophyll content (SPAD Values)
	30 DAT	60 DAT	90 DAT	30-60 DAT	60-90 DAT	30-60 DAT	60-90 DAT	
Arka Aadya	52.08	53.47	76.51	10.48	50.19	0.218	0.790	43.99
Arka Shashank	65.05	67.66	71.37	17.30	41.03	0.310	0.350	43.49
Arka Archana	63.97	81.45	81.95	25.04	66.46	0.425	0.560	44.26
ArkaPoornima	28.59	46.69	62.97	9.64	31.11	0.233	0.383	37.26
Arka Kamini	40.75	100.37	138.13	13.29	55.92	0.170	0.393	43.78
Local Pink	64.15	64.67	97.06	13.38	38.98	0.263	0.260	37.95
Local Violet (check)	27.37	27.79	42.40	5.35	18.12	0.250	0.343	39.35
SEM ±	2.80	7.06	5.10	0.15	0.88	0.028	0.051	1.27
CD (P= 0.05)	8.39	21.13	15.27	0.44	2.64	0.085	0.154	3.81

Leaf area duration

Significantly higher leaf area duration was recorded in Arka Archana (25.04, 66.46 days) between intervals of 30 to 60 and 60-90 days, respectively after transplanting (Table 3). LAR and LAD represent the leafiness and greenness of the leaves respectively. Increase in LAR values can be due to more number of leaves and the higher LAD value reports the increase in the leaf span time. More leafiness and greenness give more chlorophyll content thus producing more photosynthates resulting in more yield plant^{-1}. The reason for the above finding could be claimed as LAD in combination with an optimum leaf area index can play as an important traits for the improvement of flower yield and LAD also influences the leafiness of crop growing period. The results were in line with Kumar *et al.* (2013) in rice. The varietal differences amongst these growth analysis parameters (LAI, LAR and LAD) attributed to the variability in the genetic inheritance among the varieties (Rawat *et al*., 2015) in cluster bean.

Absolute growth rate

Arka Archana recorded the maximum absolute growth rate (0.425 g day^{-1}), at 30 to 60 days after transplanting (Table 3). While, the genotype Arka Aadya recorded maximum absolute growth rate of 0.790g day^{-1} at an interval of 60 to 90 days after transplanting. The highest absolute growth rate was due to the increase of total dry matter accumulation. The variation in leaf area and bio mass resulted in increase in absolute growth rate of the genotype studied under investigation. Similar results have been obtained by Ghosh *et al.* (2016) in tomato mutants. Higher temperature, light intensity and lower relative humidity prevailing in side shade net house favor for maximum growth analysis attributes (Table 1).

Chlorophyll content

Chlorophyll content showed significant variation among the genotypes (Table 3).The SPAD value recorded was highest (44.26) in Arka Archana. Chlorophyll content in leaf enhanced photosynthetic activity and produced carbohydrates. Carbohydrates serve as energy source for growing bud, flower opening and longevity. The ultimate effect of all these factors resulted into strong and long flower stalks, large sized buds or flower (Tarannum and Naik, 2014) in carnation. Another possible reason might be the genotype Arka Archana had significantly higher leaf number plant^{-1} and hence, resulted in maximum chlorophyll content in leaves. Leaf chlorophyll content was often highly correlated with leaf nitrogen status, photosynthetic capacity and RuBP carboxylase activity. The results were in accordance with the findings of Chowdhuri *et al.* (2016) in China aster. The amount of chlorophyll present had a direct relationship with the rate of photosynthesis because it is the pigment which is photoreceptive and is directly involved in trapping the light energy.

Table 4. Response of China aster genotypes on anthocyanin content in flowers and protein content in seeds

Genotypes	Anthocyanin content in flowers (mg 100 g^{-1})	Protein content (µg g^{-1})		
		Seeds	Leaves	Flowers
Arka Aadya	188.88	652.00	36.00	96.25
Arka Shashank	10.12	634.00	40.00	108.00
Arka Archana	9.26	580.50	12.00	132.00
Arka Poornima	9.50	588.00	36.25	66.00
Arka Kamini	177.77	568.00	40.50	133.00
Local Pink	9.51	436.00	28.00	74.00
Local Violet (check)	207.40	440.00	28.25	108.25
SEM ±	0.13	3.48	0.96	1.05
CD (P= 0.05)	0.39	10.43	2.88	3.16

Anthocyanin content in flowers

Significant differences were observed among the genotypes for anthocyanin contents (Table 4). The genotype Local Violet produced the highest anthocyanin content (207.40 mg 100 g^{-1}) which was found significantly superior over all other genotypes. The cultivars with pink, red or violet colored flowers mostly showed a greater amount of total anthocyanins. On the other hand, the cultivars with medium and low levels of anthocyanin showed light and faint colors or white in color. This might be because anthocyanin, a strong soluble pigment, mainly affects the development of violet or pink to red. A similar trend was observed by Park *et al.* (2015) in chrysanthemum.

Protein content

Significant differences were observed for protein content among genotypes (Table 4). Maximum protein content in seeds (652.00 µg g^{-1}) was recorded in genotype Arka Aadya. The genotype Arka Kamini recorded protein content of 40.50 µg g^{-1} and 133.00 µg g^{-1} in leaves and flowers, respectively. The increase in leaf area ratio with shading increases the nitrogen content in plant which was a primary constituent of protein structure. The variation in protein content in genotypes might be due to genotypic and environmental interaction. The findings of the present investigation confirm well with results reported by Atta *et al.* (2004) in Pea and Sarma *et al.* (2010) in Country bean.

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