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Correlation studies in genotypes of China aster [*Callistephus chinensis* (L.) Ness] for yield under shade net conditions in Rayalaseema Region of Andhra Pradesh

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Abstract
Seven genotypes of China aster [*Callistephus chinensis* (L.) Ness] were evaluated for genotypic correlation coefficient between flower yield and 28 quantitative traits, to understand the association between these characters and their relative contribution to flower yield. 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 was laid out in randomized block design with four replications under 50 per cent shade net condition. The aim was to bring about rational improvement in China aster. Significant positive correlation for the flower yield ha^{-1} with number of leaves $plant^{-1}$ (0.897), number of branches $plant^{-1}$ (0.893), plant spread (0.910), LAI (0.830), protein content in flowers (0.804), number of flowers $plant^{-1}$ (0.944), weight of flowers $plant^{-1}$ (0.999) and yield ha^{-1} (0.972) and negative correlation with days to first flower opening after flower initiation (-0.821). These traits may serve as effective selection parameters for breeding in China aster for improvement of the yield.

Keywords: China aster, genotypes, correlation, yield.

Introduction
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) [5]. China aster is commercially grown by marginal and small farmers in Karnataka, Tamil Nadu, Telangana, Andhra Pradesh, Maharashtra and West Bengal (Kumari *et al.*, 2017) [2]. China aster can be grown throughout the year under Bengaluru conditions. In scenario of Andhra Pradesh state, it has a great demand in local market as cut flower and potted plants, previously local varieties producing inferior flower quality were grown and the 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.

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 fetching high market prices.

Material and Methods

The present investigation on China aster [*Callistephus chinensis* (L.) Ness] 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 conducted to study the performance of China aster (*Callistephus chinensis* L.) genotypes under shade net house conditions in Rayalaseema conditions of Andhra Pradesh. The experiment was laid-out in Randomized Block Design, replicated quadruple. The trail consist of seven genotypes *viz.*, G1- Arka Aadya, G2- Arka Shashank, G3- Arka Archana, G4- Arka Poornima, G5- Arka Kamini, G6- Local pink and G7- Local violet (check). The seeds of five genotypes were collected from IIHR, Bengaluru, Local Pink from ARI, Rajendranagar, Hyderabad and Local Violet (check) from Mydukur area of Y.S.R Kadapa Dist. Ploughing and digging of the land was done and brought to fine tilth under shade net. 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 3.0 m x 1.0m.

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 daily twice, 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 per each plot at random and were labeled properly for recording observations from each genotype in each replication on various biometrical parameters and analyzed as per Panse and Sukhatme (1967) [4]. Simple correlation coefficients pertaining to phenotypic and genotypic variation for various characters in carnation genotypes were computed as per Singh and Choudhary (1979) [6]. Values for correlation coefficient (r) were calculated and the test of significance was applied as per Fisher and Yates (1963). Observations were made on correlation between qualitative and quantitative traits in different genotypes of carnation.

Results and Discussion

The simple correlation coefficients between yield and various yield components and interrelationship among the traits were computed and they are presented in Table 1. The results obtained through the correlation coefficients indicate a strong association between plant morphological characters with yield. A positive correlation between desirable characters is favorable to the plant breeder which helps in simultaneous improvement of both the characters.

Plant height had shown positive influence and had no significant correlation with other parameters *viz*., biometric, flowering, physiological, biochemical attributes, yield and flower quality parameters. Significant and positive correlation was found in number of leaves $plant^{-1}$ with other parameters *viz*., number of branches $plant^{-1}$ (0.922), plant spread (0.950), leaf area (0.861), bio mass (0.809), LAI (0.861), LAD (0.890), number of flowers $plant^{-1}$ (0.915), weight of flowers $plant^{-1}$ (0.890), yield $plot^{-1}$ (0.820), yield $hectare^{-1}$ (0.897) and flower head diameter (0.757). These findings were in line with Naikwad *et al*. (2018) in China aster.

Number of branches $plant^{-1}$ shown positive effect and significantly related to number of leaves $plant^{-1}$ (0.922), plant spread (0.950), leaf area (0.929), LAI (0.929), LAD (0.866), AGR (0.793), number of flowers $plant^{-1}$ (0.843), weight of flowers $plant^{-1}$ (0.900), yield $plot^{-1}$ (0.783) and yield ha^{-1} (0.893). Plant spread at full bloom shown positive and significant effect on leaf area (0.889), bio mass (0.820), LAI (0.889), LAD (0.868), AGR (0.801), chlorophyll (0.795), number of flowers $plant^{-1}$ (0.862), weight of flowers $plant^{-1}$ (0.912), yield $plot^{-1}$ (0.807) and yield ha^{-1} (0.910).

Days to first flower bud initiation exhibited positive and significant relation with days to first flower opening (0.803), days to 50% flowering (0.954) and days to first harvesting of mature flower (0.997) but negatively and significant relation with chlorophyll content in leaves (-0.826) whereas longevity of flower on the plant shown no significant relation with any other parameters *viz*., biometric, flowering, physiological, biochemical attributes, yield and flower quality parameters.

Significant and positive correlation was shown by leaf area $plant^{-1}$with parameters viz., number of leaves $plant^{-1}$ (0.861), number of branches $plant^{-1}$ (0.929), plant spread (0.889), LAI (1.000), LAD (0.963), number of flower $plant^{-1}$ (0.880), weight of flowers $plant^{-1}$ (0.837) and yield ha^{-1} (0.830). Similar correlation for leaf area was reported by Tirakannanavar *et al*. (2015) [7] in China aster genotypes.

Bio mass $plant^{-1}$ had significant and positive correlation with parameters like number of leaves $plant^{-1}$ (0.793), plant spread at full bloom (0.801) and AGR (0.903). Anthocyanin content in flowers showed positive and non significant correlation with protein content in leaves (0.282) and flowers (0.338) but negative and non significant correlation with protein content in seeds (-0.083) of China aster.

Significant positive correlation for the flower yield ha^{-1} with number of leaves $plant^{-1}$ (0.897), number of branches $plant^{-1}$ (0.893), plant spread (0.910), LAI (0.830), protein content in flowers (0.804), number of flowers $plant^{-1}$ (0.944), weight of flowers $plant^{-1}$ (0.999) and yield ha^{-1} (0.972) and negative correlation with days to first flower opening after flower initiation (-0.821). With respect to qualitative parameters, length of flower stalk exhibited positive and highly significant correlation with protein content in leaves (0.852) and vase life (0.865).

Flower yield in China aster showed good positive relationship with vegetative parameters like number of leaves $plant^{-1}$, number of branches $plant^{-1}$, plant spread, and physiological parameters like LAI, protein content in flowers. This may have resulted in production of superior flower quality parameters like weight of flowers $plant^{-1}$, thereby, flower diameter and circumference and ultimately, increased number of flowers per plant. Hence, selection of the above, stable characters will help improve flower yield. These characters should be accorded emphasis in selection for improvement in carnation.

Table 1: Correlation between yield and various parameters in different China aster genotypes

	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17	x18	x19	x20	x21	x22	x23	x24	x25	x26	x27	x28	x29
x1	1.000																												
x2	0.503	1.000																											
x3	0.275	0.922**	1.000																										
x4	0.430	0.950**	0.979**	1.000																									
x5	-0.087	-0.376	-0.428	-0.481	1.000																								
x6	-0.276	-0.687	-0.662	-0.743	0.803*	1.000																							
x7	0.080	-0.211	-0.328	-0.358	0.954**	0.742	1.000																						
x8	-0.108	-0.423	-0.465	-0.522	0.997**	0.843*	0.948**	1.000																					
x9	0.427	0.354	0.465	0.478	-0.054	-0.217	-0.156	-0.069	1.000																				
x10	0.252	0.861*	0.929**	0.889**	-0.490	-0.593	-0.422	-0.515	0.535	1.000																			
x11	0.529	0.809*	0.741	0.820*	-0.536	-0.679	-0.298	-0.563	0.037	0.581	1.000																		
x12	0.253	0.861*	0.929**	0.889**	-0.489	-0.593	-0.421	-0.514	0.535	1.000**	0.581	1.000																	
x13	-0.179	0.317	0.465	0.343	-0.133	-0.105	-0.257	-0.136	0.592	0.698	-0.176	0.698	1.000																
x14	0.422	0.890**	0.866*	0.868*	-0.513	-0.657	-0.428	-0.544	0.543	0.963**	0.591	0.964**	0.639	1.000															
x15	0.223	0.700	0.793*	0.801*	-0.486	-0.545	-0.302	-0.501	0.058	0.612	0.903**	0.611	-0.043	0.505	1.000														
x16	0.308	0.643	0.746	0.795*	-0.826*	-0.862*	-0.809*	-0.844*	0.545	0.753	0.614	0.752	0.364	0.754	0.600	1.000													
x17	-0.653	-0.089	0.228	0.141	-0.173	-0.208	-0.300	-0.177	-0.026	0.044	0.006	0.043	0.051	-0.163	0.340	0.240	1.000												
x18	0.647	0.491	0.568	0.633	-0.369	-0.307	-0.255	-0.361	0.591	0.535	0.632	0.534	0.096	0.510	0.645	0.637	-0.083	1.000											
x19	-0.257	-0.524	-0.232	-0.302	0.113	0.486	-0.037	0.168	0.342	-0.147	-0.416	-0.149	0.209	-0.298	-0.119	-0.031	0.282	0.323	1.000										
x20	0.130	0.493	0.557	0.603	-0.567	-0.842*	-0.659	-0.610	0.545	0.529	0.278	0.529	0.367	0.573	0.218	0.804*	0.338	0.186	-0.240	1.000									
x21	0.374	0.915**	0.843*	0.862*	-0.503	-0.782*	-0.423	-0.552	0.424	0.880**	0.600	0.881**	0.521	0.946**	0.462	0.723	-0.092	0.310	-0.541	0.697	1.000								
x22	-0.128	0.359	0.538	0.532	-0.141	-0.521	-0.203	-0.185	0.297	0.273	0.321	0.273	0.024	0.167	0.471	0.460	0.774*	0.140	-0.088	0.658	0.313	1.000							
x23	0.279	0.890**	0.900**	0.912**	-0.447	-0.817*	-0.404	-0.502	0.490	0.837*	0.608	0.837*	0.455	0.850*	0.552	0.764*	0.195	0.332	-0.455	0.808*	0.938**	0.620	1.000						
x24	0.316	0.820*	0.783*	0.807*	-0.341	-0.767*	-0.333	-0.401	0.543	0.749	0.454	0.750NS	0.477	0.808*	0.341	0.679	0.082	0.213	-0.507	0.840*	0.925**	0.563	0.969**	1.000					
x25	0.299	0.897**	0.893**	0.910**	-0.444	-0.821*	-0.395	-0.500	0.480	0.830*	0.615	0.830*	0.439	0.851*	0.546	0.756*	0.170	0.326	-0.481	0.804*	0.944**	0.606	0.999**	0.972**	1.000				
x26	0.026	0.754	0.729	0.678	-0.227	-0.384	-0.025	-0.257	-0.222	0.618	0.726	0.619	0.119	0.542	0.767*	0.254	0.135	0.167	-0.501	0.040	0.575	0.251	0.558	0.404	0.561	1.000			
x27	0.420	0.085	0.235	0.277	-0.383	-0.113	-0.397	-0.350	0.651	0.334	0.201	0.333	0.238	0.309	0.265	0.558	-0.069	0.852*	0.659	0.160	0.056	-0.064	0.048	-0.020	0.035	-0.270	1.000		
x28	0.030	0.757*	0.730	0.680	-0.226	-0.385	-0.023	-0.255	-0.220	0.618	0.728	0.619	0.118	0.543	0.768*	0.254	0.132	0.169	-0.503	0.041	0.577	0.252	0.560	0.406	0.562	1.000**	-0.270	1.000	
x29	0.466	0.098	0.133	0.196	-0.484	-0.228	-0.527	-0.459	0.649	0.359	0.056	0.358	0.389	0.438	-0.030	0.573	-0.342	0.624	0.413	0.309	0.239	-0.279	0.113	0.134	0.109	-0.390	0.865*	-0.389	1.000

*Significant at p = 0.05 probability, ** Significant at p = 0.01 probabilit

X1. Plant height	X9. Longevity of flower on the plant	X17.Anthocyanin content in flowers	X25.Flower yield
X2. Number of leaves plant^{-1}	X10.Leaf area plant^{-1}	X18.Protein content in seeds	X26.Flower head circumference
X3. Total number of branches plant^{-1}	X11.Bio mass plant^{-1}	X19.Protein content in leaves	X27.Length of flower stalk
X4. Plant spread	X12.Leaf area index	X20.Protein content in flowers	X28.Flower head diameter
X5. Days to first flower bud initiation	X13.Leaf area ratio	X21.Number of flowers plant^{-1}	X29.Vase life
X6. Days to first flower opening	X14.Leaf area duration	X22.Individual flower weight	
X7. Days to 50% flowering	X15.Absolute growth rate	X23.Weight of flowers plant^{-1}	
X8. Days to first harvesting of mature flower	X16.Chlorophyll content in leaves	X24.Flower yield plot^{-1}	

Appendix I: Monthly mean temperature (^{0}C), relative humidity (%) and light intensity (lux) during the investigation period

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

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