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# Nature of gene action for growth, yield and quality traits in China aster (*Callistephus chinensis* (L.) Nees)

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**Abstract**
Selection of suitable breeding methodologies in bringing desirable improvement in crop plant require the complete knowledge about the nature of gene action involved in the inheritance of quantitative and quality traits. Gene action of growth, yield and quality traits in China aster (*Callistephus chinensis* (L.) Nees.) were studied through line x tester analysis of 27 $F_1$ hybrids derived by crossing of nine lines and three testers. The present study indicated the preponderance of non-additive gene action for plant height (cm), plant spread (cm), number of branches per plant, days for first flowering, days for 50 percent flowering, duration of flowering (days), flower diameter (cm), flower stalk length (cm), vase life (days), shelf life (days), number of flowers per plant, individual flower weight (g) and flower yield per plant (g). Due to expression of non-additive gene action for all parameters under study exhibited, heterosis breeding is required to be followed for exploitation of these traits.

**Keywords:** Gene action, china aster, variance, non-additive, traits

## Introduction
China aster (*Callistephus chinensis* (L.) Nees.), is an important commercial flower crop of family Asteraceae. It is diploid with chromosome number 2n=18 and is originated in China. The genus *Callistephus* is derived from two Greek words *Kalistos* and *Stephus* referes to 'most beautiful' and 'a crown' (flower head) respectively. It was first named by Linnaeus as *Aster chinensis* and later Nees changed this name to *Callistephus chinensis* (Janakiram, 2006) [7]. During 18$^{th}$ century, it was introduced to Europe and other tropical countries (Bailey, 1963) [2]. Among the traditional flower crops cultivated for both loose and cut flowers, the china aster has gained popularity among small and marginal farmers in India due to it's ease of cultivation (Singh, 2006) [10].
The ornamental plant industry is highly dynamic and always demands constant novelties. The existing commercial cultivars in India have semi-double flowers with prominent disks and short flower stalks with less vase life. Hence, development of china aster for both cut and loose flowers needs improvement in growth, yield and quality attributes such as plant height, number of branches, flower yield, flower color, flower stalk length, shape, flower size and increased vase life. It is commercially grown by marginal and small farmers in the states of Tamil Nadu, Karnataka, Maharashtra, Andhra Pradesh and West Bengal. In Karnataka it is widely cultivated in the districts like Bangalore, Tumkur, Kolar, Chikkaballapur and Belagavi.
Understanding the genetic system that governs yield and it's associated traits is crucial for designing an effective selection program using an appropriate mating strategy. It is vital to have insights into the relative contributions of various components of variation, such as additive and non-additive factors, to enhance the efficiency of crop improvement initiatives. Line x Tester analysis is an effective biometrical technique for the genetic analysis of the quantitative characters and for the precise estimation of combining ability effects. Griffing's numerical approach is based on the estimation of GCA and SCA variances and effects. This method provides a sensitive approach to large scale studies of quantitative characters, reliable information on the components of variance and on the GCA and SCA variances and effects.

## Materials and Methods
Nine lines (Arka Poornima, Arka Archana, Phule Ganesh Pink, Phule Ganesh White, Miraj Local, Namdhari White, Namdhari Pink, Local Pink and Local White) and three testers (AAC-1, Phule Ganesh Purple and Arka Kamini) were crossed in line × tester mating design to

develop 27 $F_1$ hybrids during 2021-23 at Floriculture unit, Department of Horticulture, University of Agricultural Sciences, GKVK, Bengaluru. The twelve parents, twenty seven $F_1$ hybrids and standard check (Arka Kamini) were planted in randomized complete block design (RCBD) with two replications at spacing of 30 cm × 30 cm. Uniform cultural practices were followed for proper growth and development. Five plants were tagged to record the observations on plant height (cm), plant spread (cm), number of branches per plant, days for first flowering, days for 50 percent flowering, duration of flowering (days), flower diameter (cm), flower stalk length (cm), vase life (days), shelf life (days), number of flowers per plant, individual flower weight (g) and flower yield per plant (g). Components of genetic variance were estimated from the data obtained on the line × tester crosses by the method given by Griffing's Method-II and Model-I (Griffing, 1956) [6] as outlined by Singh and Chaudhary (1985) [11].

## Results and Discussion

For effective planning of breeding program, information regarding the combining ability studies in terms of GCA and SCA variance is needed. This information also provides insights into the genetic mechanisms governing a particular trait. Specifically, SCA variance helps to identify the non-additive gene effects, whereas GCA variance quantifies the additive gene effects for the trait. Interpreting the ratio between GCA and SCA variances aids in understanding the relative significance of additive and non-additive gene actions in the trait's expression.

If the ratio of additive to non-additive gene action exceeds the unity, it suggests that additive variance plays a predominant role in influencing trait expression. Conversely, if the ratio is less than unity, it signifies the greater significance of non-additive variance. In the present investigation, an attempt was made to obtain information on the magnitude of GCA and SCA variance for all growth, yield and quality parameters in China aster.

### Analysis of Variance due to lines, testers and line × tester interaction

Variance due to lines, testers and line × tester interaction with respect to all growth, yield and quality parameters under study are represented in Table 1. The analysis of variance indicated that highly significant variability was recorded for all characters under study. The variance due to lines was significant for Plant spread (cm), number of branches per plant, days to first flowering, duration of flowering (days) and flower yield per plant (g). The variance due to testers was significant for plant height, plant spread, number of branches per plant, days for first flowering, duration of flowering (days) and individual flower weight (g). Similarly, line × tester interaction was highly significant for all characters under study.

### Gene Action for growth, yield and quality parameters

Understanding the genetic basis of economic traits is widely acknowledged as a crucial factor in advancing breeding efforts and fostering the development of novel crop varieties. The variances associated with GCA and SCA are connected to the type of gene action present. GCA variance encompasses the additive portion, whereas SCA variance comprises the non-additive portion of the total variance, primarily stemming from dominance and epistatic deviations. Further, it is also essential to partition heritable variation into additive gene action (fixable) and non-additive (non-fixable) components. In the present study, estimation of variance components, ($\sigma^2$GCA and $\sigma^2$SCA) and their ratios were represented Table 2.

### Growth parameters

The component of variance due to SCA (1.62) was of higher order than GCA (0.61) and the ratio of GCA to SCA variance (0.37) was less than unity for plant height. This ratio indicates the significance of dominance gene action in influencing the expression of this trait.

For the trait plant spread it's notable that the specific combining ability (SCA) variance (1.05) was significantly higher than the general combining ability (GCA) variance (0.36). This observation underscores the substantial influence of non-additive gene action as the primary factor for the expression of this trait.

The SCA variance (1.98) for the trait number of branches per plant at 30 days after transplanting was found maximum than GCA variance (0.08) and the ratio of GCA to SCA variance (0.04) was less than one illustrating the significance of dominant gene effect.

Similar action of pronounced SCA variance for growth parameters were described by Bayat *et al.* (2012) [3] in petunia, Kattera *et al.* (2014) [8] in chrysanthemum, Anjali *et al*. (2016) [1] in china aster and Cvejic *et al.* (2017) [5] in ornamental sunflower.

### Flower parameters

Variance due to SCA (5.32) was high compared to GCA (2.40) for days to first flowering. Moreover, the ratio of GCA to SCA variance (0.45) was less than one, indicating the prevailing influence of non-additive gene action in determining the expression of this particular trait. In context to days to 50 percent flowering, it's noteworthy that significant SCA variance (7.58) was surpassing the GCA variance (3.28). This underscores the dominant role of non-additive gene action over additive gene action in influencing this trait.

For the expression of the trait duration of flowering, maximum variance attributed to specific combining ability (1.58) was recorded as compared to general combining ability variance (1.22). This suggests a predominant influence of non-additive gene action on the trait, which is consistent with earlier findings reported by Kattera *et al.* (2014) [8] in chrysanthemum and Anjali *et al.* (2016) [1] in china aster.

### Yield parameters

For trait number of flowers per plant, it's important to highlight that the SCA variance (8.67) was surpassing the GCA variance (3.00). Furthermore, the ratio of GCA to SCA variance (0.34) was less than unity, underscoring the importance of dominant gene effects. Variance due to SCA (0.04) was greater than the GCA (0.01) variance for individual flower weight. Consequently, type of gene action involved in the expression of this trait was non-additive type.

The variance of specific combining ability (70.98) for flower yield per plant was greater than variance of general combining ability (47.39) and the ratio of GCA to SCA variance (0.66) was less than unity portrayed the significance of dominant gene effect. Similar results were recorded by Bhargav *et al.* (2019) [4] in china aster and Mahato *et al*. (2020) [9] in gladiolus.

### Flower quality parameters

In the context of flower diameter, it's evident that the specific combining ability variance (0.04) was notably higher as compared to the general combining ability variance (0.01). Additionally, the ratio of GCA to SCA variance (0.25) was less than one, indicating the prevailing dominance of non-additive gene action in determining this trait. The data analysed for combining ability unveiled that SCA variance (1.89) was maximum than the GCA variance (1.18) for flower stalk length. The ratio of GCA to SCA variance recorded less than unity (0.62), rendered the predominance of non additive gene action over additive gene action for flower stalk length.

In the present study, SCA variance (0.18) was observed maximum than the GCA variance (0.15) for the trait vase life of cut flowers. Furthermore, the ratio of GCA to SCA variance (0.83) was less than unity indicated the dominance of non-additive gene action over additive gene action in this context. The variance attributed to specific combining ability (0.04) for shelf life was notably higher in comparison to the general combining ability variance (0.02). Consequently, it depicts that the gene action influencing the expression of this trait is primarily of the non-additive type. These results were in conformity with Bhargav *et al.* (2019) [4] in china aster and Rivera *et al.* (2019) [12] gerbera and Mahato *et al*. (2020) [9] in gladiolus.

**Table 1:** Analysis of variance due to lines, testers and line × tester interaction for growth, yield and quality traits in china aster

| Sl. No. | Characters | Mean sum of squares | | |
|---|---|---|---|---|
| | Degrees of freedom | Line effect | Tester effect | L × T effect |
| | | 8 | 2 | 16 |
| 1. | Plant height (cm) | 39.50 | 117.11* | 3.32** |
| 2. | Plant spread (cm) | 25.44 | 59.98 | 2.29* |
| 3. | Number of branches per plant | 11.68** | 9.76* | 1.46* |
| 4. | Days for first flowering | 211.32* | 218.76* | 10.81** |
| 5. | Days for 50 percent flowering | 296.16 | 273.10 | 19.48** |
| 6. | Duration of flowering (days) | 102.38* | 121.31* | 3.17** |
| 7. | Flower diameter (cm) | 1.84 | 0.29 | 0.08* |
| 8. | Flower stalk length (cm) | 100.19 | 113.59 | 3.87** |
| 9. | Vase life (days) | 13.00 | 110.86 | 0.43* |
| 10. | Shelf life (days) | 2.70 | 0.88 | 0.08* |
| 11. | No. of flowers per plant | 243.88 | 414.13 | 25.92** |
| 12. | Individual flower weight (g) | 0.92 | 2.70* | 0.08* |
| 13. | Flower yield per plant (g) | 4936.18* | 869.23 | 142.83** |

*Significant at 5 percent level **Significant at 1 percent level

**Table 2:** Estimates of variance components in respect of growth, yield and quality traits in china aster

| Sl. No. | Characters | Component of variance | | |
|---|---|---|---|---|
| | | $\sigma^2$ GCA | $\sigma^2$ SCA | $\sigma^2$ GCA : $\sigma^2$ SCA |
| 1. | Plant height (cm) | 0.61 | 1.62 | 0.37 |
| 2. | Plant spread (cm) | 0.36 | 1.05 | 0.34 |
| 3. | Number of branches per plant | 0.08 | 1.98 | 0.04 |
| 4. | Days for first flowering | 2.40 | 5.32 | 0.45 |
| 5. | Days for 50 percent flowering | 3.28 | 7.58 | 0.43 |
| 6. | Duration of flowering (days) | 1.22 | 1.58 | 0.77 |
| 7. | Flower diameter (cm) | 0.01 | 0.04 | 0.25 |
| 8. | Flower stalk length (cm) | 1.18 | 1.89 | 0.62 |
| 9. | Vase life (days) | 0.15 | 0.18 | 0.83 |
| 10. | Shelf life (days) | 0.02 | 0.04 | 0.50 |
| 11. | No. of flowers per plant | 3.00 | 8.67 | 0.34 |
| 12. | Individual flower weight (g) | 0.01 | 0.04 | 0.25 |
| 13. | Flower yield per plant (g) | 47.39 | 70.98 | 0.66 |

## Conclusion

Adequate genetic variability for yield and it's contributing traits was achieved by crossing twelve distinct elite genotypes of china aster using a line x tester mating design. In most of the studied parameters, the specific combining ability (SCA) variance was greater than the general combining ability (GCA) variance. This suggests that non-additive gene action predominates over additive gene action in the majority of the traits. The presence of non-additive gene action revealed that heterosis breeding is required to be followed for further improvement of China aster.

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