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Study of combining ability on growth traits in annual chrysanthemum (*Glebionis coronaria* [L.] Cass. ex Spach.)

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Abstract
Study of combining ability on growth traits in annual chrysanthemum (*Glebionis coronaria* [L.] Cass. ex Spach.) Was undertaken to the study general and specific combining ability of parents to identify superior parents and crosses crosses respectively. A line x tester analysis was carried out involving five lines (White Majestine, AACS-3, Sarpan White, Sarpan Yellow and Garden Aids) and three testers (Dharwad White, Dharwad Yellow and Bagalkot Local) to obtain fifteen crosses. The experiment was conducted at the Department of Floriculture and Landscape Architecture, Kittur Rani Channamma College of Horticulture, Arabhavi, Karnataka during 2020-21. The parent White Majestine and Sarpan White were good general combiners for the majority of the traits. The cross combination Sarpan White × Dharwad White, Sarpan White × Bagalkot Local and Sarpan Yellow x Bagalkot Local are the best specific combining ability for various trait.

Keywords: Annual chrysanthemum, general combing ability, specific combining ability

Introduction
Glebionis coronaria (L.) Cass. ex Spach. often known as *Chrysanthemum coronarium* L., is a flowering plant in the Asteraceae family. It is abundant throughout Europe, Northern Africa and Asia and is endemic to the Mediterranean area. Garland chrysanthemum, edible chrysanthemum, crown daisy chrysanthemum, kikuna, mirabeles, shungiku, chop suey green, crown daisy and Japanese green are just a few of common names. The annual chrysanthemum has the potential to appear at any time of the year. They are self-fertile hermaphrodites that reproduce by seed.
It contrasts from the Florist's Chrysanthemum in a number of ways, including its shorter bloom time, lower photosensitivity and ability to grow higher, more vigorously and more hardily. It's a bipinnately lobed leaf herb with yellow ray florets and a tiny fragrant flower head. It is a branching annual with finely cut leaves that may reach a height of one meter. The blooms are 2.5-4 cm in diameter and occur in single or double forms (Desai, 1962) [5] with cream zones in the center (Vishnu swarup, 1967) [11]. India has a total area of 16.63 million hectares under loose flower production, with a production of 179.33 million tonnes. Tamil Nadu, Karnataka, Maharashtra, Rajasthan, Madhya Pradesh and Bihar are some of India's top chrysanthemum-growing states (Anon., 2014) [2].
A lot of variability for flower characters is available in annual chrysanthemum, In the market, importance is given to annual chrysanthemum flowers having a small disc, a greater number of petals with large size, multi-layered whorls of petals with multicolor. Estimation of combining ability is an important tool which can be utilized in the design of successful breeding programs in various ornamental crops (Bayat *et al*., 2012) [3]. To understand the probable use of any genotype as a good line or tester parent in hybridization, there is a need to evaluate its own performance along with its gca effect and the performance of F1 hybrid derived from it. General combining ability (gca) of genotypes is normally associated with additive gene action, while specific combining ability (sca) governed by dominance and epistasis gene action (Malik *et al*., 2004) [7]. Parents differing in their combining ability and the use of good general combiners are expected to give useful segregants. In similar way, superior cross combinations

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can be categorized in respect to their specific combining ability effects. It also provides necessary information on nature and magnitude of gene effects for growth traits.

Material and Methods
This study was conducted in the research field of the Department of Floriculture and Landscape Architecture of Kittur Rani Channamma College of Horticulture, Arabhavi, Karnataka during 2020-21. The experimental material comprised eight genotypes of the annual chrysanthemum. Five lines namely White Majestine, AACS-3, Sarpan White, Sarpan Yellow and Garden Aids were crossed with three testers namely Dharwad White, Dharwad Yellow and Bagalkot Local in line × tester mating design to develop ten F_1 hybrids. Hand pollination of five lines was done with three testers in fifteen combinations. The lines, testers and hybrids were planted in a randomized complete block design (RCBD) with two replications at a spacing of 60 cm × 30 cm. Uniform cultural practices were followed in all the hybrids, lines and testers.
The observations were recorded for namely plant height, number of branches, Plant spread, Number of leaves and Leaf area. The data generated was used to estimate general combining ability of parents and specific combining ability of cross combinations using appropriate formulae and statistical package WINDOSTAT version 8.6.

Result and Discussion
The variances of general combining ability (GCA) and specific combining ability (SCA) of growth characters studied are presented in Table 1. Results of the investigation revealed that, plant height and plant spread (N-S) reported higher SCA variance and for the trait number of branches, plant spread (E-W), number of leaves per plant and leaf area GCA variance was maximum.
General combining ability (gca) and Specific combining ability (sca) effects for growth parameters in annual chrysanthemum were furnished in Table 2 and Table 3 respectively.
 Plant height is an important vegetative trait that determines the growth and vigorousness of the plant. Decreased plant height is a desirable trait for avoiding the lodging of the plant. White Majestine was the best general combiner as it exhibited negative significant gca effects. Thus, the parents possess additive genes for the trait. Sarpan Yellow × Dharwad White and Sarpan White × Bagalkot Local reported maximum negative significant sca effects. Here, crosses have female parents of low gca and male parents of high gca and female parents of low gca and male parents of low gca, respectively. This indicates the additive × dominant and dominant × dominant type of gene action respectively and hence can be exploited by heterosis breeding or recurrent selection.
Among eight parents, three parents reported positive gca effects and five reported negative gca effects. AACS-3 (6.59) was the parents that exhibited significant positive gca effects. White Majestine (-2.98) reported significant negative gca effects. Among fifteen crosses, AACS-3 × Dharwad White (8.65), White Majestine × Bagalkot Local (4.54), Sarpan Yellow × Bagalkot Local (3.67), Sarpan White × Dharwad Yellow (3.61), and Sarpan Yellow × Bagalkot Local (3.67) showed significant positive sca effects Sarpan Yellow × Dharwad White (-6.25), Sarpan White × Bagalkot Local (-4.89), AACS-3 × Bagalkot Local (-4.83) and AACS-3 × Dharwad Yellow (-3.83) crosses exhibited significant negative sca effects.

The number of branches is an important parameter contributing to productivity. It decides the density of the plant. Two parents reported significant gca effects in both directions and the rest of the six parents were non-significant. Garden Aids was the only parent that reported a significant positive gca effect. Hence, Garden Aids could be considered as the best general combiner for the number of branches and possesses additive genes for this trait. None of the crosses showed significance for sca effects. Sarpan Yellow × Bagalkot Local showed the highest values for the sca effect. In this cross, the female parent was with higher gca and the male parent was with lower gca hence indicating additive × dominant type of gene action and can be exploited by heterosis breeding and recurrent selection. These results are also in agreement with the results of Anjali (2015) [1], Bhargav et al. (2019a) [4] and Mrutyunjaya (2021) [8] in China aster Garden Aids (2.51) was the parents that exhibited significant positive gca effects. White Majestine (-2.59) reported significant negative gca effects. Among eight parents, three parents reported positive gca effects and five reported negative gca effects. Among fifteen crosses, ten crosses showed negative sca effects while the other five crosses exhibited positive sca effects, none of the crosses showed a significant sca effect in both directions
Plant spread in an east-west direction, the magnitude of gca effect ranged from -3.13 to 3.97 and three parents exhibited significant gca effects. AACS-3 (3.97) and Dharwad Yellow (2.40) showed positive significance whereas, White Majestine (-3.13) showed negative significant gca effects. Among fifteen two crosses exhibited positive significant sca effects and one cross exhibited negative significant sca effect. The magnitude of the sca effect ranged from -3.88 (AACS-3 × Bagalkot Local) to 4.47 (Sarpan White × Bagalkot Local).
Plant spread in a north-south direction, the magnitude of gca effect ranged from -3.84 to 3.22 and five parents exhibited significant gca effects. AACS-3 (3.22), Sarpan Yellow (2.32) and Dharwad Yellow (1.96) showed positive significance whereas, White Majestine (-3.84) and Bagalkot Local (-1.69) showed negative significant gca effects. Three cross combinations viz., Sarpan Yellow × Dharwad Yellow (-4.69), AACS-3 × Dharwad White (-3.36), Sarpan Yellow × Dharwad White (3.64), Sarpan White × Bagalkot Local (4.39) and AACS-3 × Dharwad Yellow (4.81) had significant sca effects in both the directions. The rest of the ten crosses showed non-significant sca effects
For number of leaves per plant, three parents White Majestine, Sarpan White and Dharwad White showed positive significant gca effects and appeared to possess additive genes. Two crosses Sarpan White × Bagalkot Local and Garden Aids × Dharwad Yellow showed a positive significant sca effect. thus, the crosses of the gca combination were of high × low and high × high type, respectively indicating additive × dominant and additive × additive type of gene action and these can be exploited by heterosis breeding or recurrent selection. The mean sum of squares was significant for line and line × tester effect and variance due to GCA was high compared to SCA. Hence, additive gene action played the main role in the expression of this character. These results are in conformity with Singh and Mishra (2010) [10] in marigold, and Kattera et al. (2014) [6] in annual chrysanthemum
The top two parents that resulted in maximum gca effects were White Majestine (92.30) and Sarpan White (34.30). Six parents exhibited significant gca effects while, two parents were non-significant. Five crosses among fifteen reported significant sca effects while, ten crosses were non-significant.

Positive significant sca effects were exhibited by Garden Aids × Dharwad Yellow (39.60) and Sarpan White × Bagalkot Local (36.60).and negative significant sca effects were exhibited by Garden Aids × Dharwad White (-43.70), Sarpan Yellow × Bagalkot Loca (-32.23) and Sarpan White × Dharwad Yellow (-31.40) For leaf area, the top two parents that resulted in maximum gca effects were Garden Aids (50.13) and Sarpan Yellow (14.13). Two parents *viz.*, Garden Aids (50.13) and White Majestine (-51.87) showed significant gca effects and six were non-significant for the number of leaves per plant. Ten crosses exhibited a negative sca effect and five crosses exhibited a positive sca effect. The magnitude of the sca effect ranged from -27.73 (Sarpan Yellow × Dharwad White) to 35.87 (Sarpan Yellow × Bagalkot Local).

Table 1: Variance due to general and specific combining ability and their ratio for growth traits in annual chrysanthemum

Sl. No.	Sources		Mean sum of squares			Component of variance		
	Degrees of freedom		Line effect	Tester effect	L × T effect	**GCA**	**SCA**	**VA/VD**
			4	**2**	**8**			
1	Plant height (cm)		85.27	1.49	61.34	9.53	28.05	0.34
2	No. of branches per plant		20.65	0.32	3.19	1.63	-0.39	-4.14
3	Plant spread (cm)	E-W	43.13	43.95	18.13 **	9.61	6.52	1.47
		N-S	50.68	33.85	29.12 **	9.37	12.17	0.77
4	No of leaves per pant		8260.53 *	128.53	1274.53	651.28	-157.44	-4.14
5	Leaf area(cm2)		28620.53 **	6686.80	2165.13 **	4338.81	933.36	4.65

*Significant at 5 per cent level **Significant at 1 per cent level GCA - General combining ability
SCA - Specific combining ability

Table 2: General combining ability (*gca*) effects for growth parameter in annual chrysanthemum

Sl. No.	Parents	Plant height (cm)	No. of branches	Plant spread (cm)		No of leaves/pant	Leaf area(cm²)
				E-W	**N-S**		
1	White Majestine	-2.98 **	-2.59 **	-3.13 **	-3.84 **	-51.87 **	92.30 **
2	AACS-3	6.59 **	-0.13	3.97 **	3.22 **	-2.53	-86.03 **
3	Sarpan White	-1.55	-0.49	-0.88	0.09	-9.87	34.30 **
4	Sarpan Yellow	-1.21	0.71	1.12	2.32 *	14.13	-44.37 **
5	Garden Aids	-0.85	2.51**	-1.08	-1.79	50.13 **	3.8
	S.Esij	0.94	0.81	0.92	0.89	16.28	7.05
	C.D. at 5%	2.01	1.75	1.98	1.92	34.91	15.13
	C.D. at 1%	2.78	2.42	2.74	2.66	48.45	20.99
	Tester						
6	Dharwad White	0.28	-0.11	-1.49	-0.27	-2.27	18.20 **
7	Dharwad Yellow	0.16	-0.09	2.40 **	1.96 *	-1.87	11.4
8	Bagalkot Local	-0.44	0.21	-0.90	-1.69 *	4.13	-29.60 **
	S.Esij	0.72	0.81	0.71	0.69	12.61	5.46
	C.D. at 5%	1.55	1.75	1.53	1.48	27.04	11.72
	C.D. at 1%	2.16	2.42	2.12	2.06	37.53	16.26

*Significant at 5 per cent level **Significant at 1 per cent level

Table 3: Specific combining ability (*sca*) effects for growth parameter in annual chrysanthemum

Sl. No.	Crosses	Plant height (cm)	No. of branches	Plant spread (cm)		No of leaves/ pant	Leaf area (cm2)
				E-W	**N-S**		
1	White Majestine × Dharwad White	-2.68	1.31	0.31	1.90	26.27	11.3
2	White Majestine × Dharwad Yellow	-1.86	-0.71	-0.38	0.87	-14.13	2.1
3	White Majestine × Bagalkot Local	4.54 *	-0.61	0.07	-2.78	-12.13	-13.4
4	AACS-3 × Dharwad White	8.65 **	-0.35	0.06	-3.36 *	-7.07	18.63
5	AACS-3 × Dharwad Yellow	-3.83 *	0.53	3.82 *	4.81 **	10.53	-23.57
6	AACS-3 × Bagalkot Local	-4.83 **	-0.17	-3.88 *	-1.44	-3.47	4.93
7	Sarpan White × Dharwad White	1.29	1.31	-2.49	-2.53	26.27	-5.2
8	Sarpan White × Dharwad Yellow	3.61 *	-0.31	-1.98	-1.86	-6.13	-31.40 *
9	Sarpan White × Bagalkot Local	-4.90 **	-1.01	4.47 *	4.39 *	-20.13	36.60 **
10	Sarpan Yellow × Dharwad White	-6.25 **	-1.39	2.56	3.64 *	-27.73	18.97
11	Sarpan Yellow × Dharwad Yellow	2.57	-0.41	-2.23	-4.69 **	-8.13	13.27
12	Sarpan Yellow × Bagalkot Local	3.67 *	1.79	-0.33	1.06	35.87	-32.23 *
13	Garden Aids × Dharwad White	-1.01	-0.89	-0.44	0.35	-17.73	-43.70 **
14	Garden Aids × Dharwad Yellow	-0.49	0.89	0.77	0.87	17.87	39.60 **
15	Garden Aids × Bagalkot Local	1.51	-0.01	-0.33	-1.227	-0.13	4.1
	S.Esij	1.62	1.41	1.60	1.5481	28.19	12.22
	C.D. at 5%	3.47	3.02	3.42	3.3202	60.46	26.20
	C.D. at 1%	4.82	4.20	4.75	4.6083	83.92	36.36

*Significant at 5 per cent level **Significant at 1 per cent level
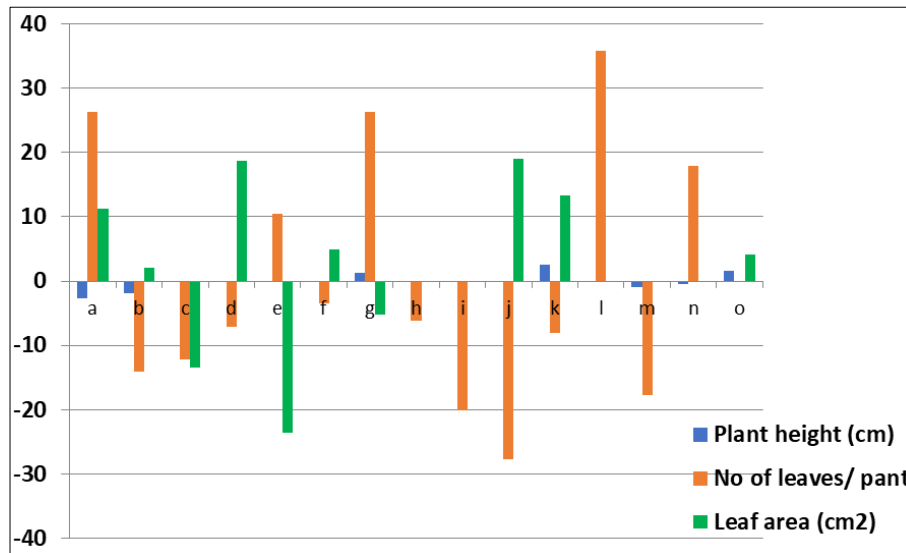
Fig 1: Estimates of *sca* effect of hybrids for growth characters

a)	White Majestine × Dharwad White	b)	White Majestine × Dharwad Yellow	c)	White Majestine × Bagalkot Local	d)	AACS-3 × Dharwad White	e)	AACS-3 × Dharwad Yellow
f)	AACS-3 × Bagalkot Local	g)	Sarpan White × Dharwad White	h)	Sarpan White × Dharwad Yellow	i)	Sarpan White × Bagalkot Local	j)	Sarpan Yellow × Dharwad White
k)	Sarpan Yellow × Dharwad Yellow	l)	Sarpan Yellow × Bagalkot Local	m)	Garden Aids × Dharwad White	n)	Garden Aids × Dharwad Yellow	o)	Garden Aids × Bagalkot Local

Conclusions
From the studies it is concluded that the parent White Majestine followed by Sarpan White were good general combiners for plant height and leaf area, Garden Aids was a good general combiner for the number of branches per plant, this indicates additive gene action.

The cross Sarpan White × Dharwad White reported a significant negative *sca* effect for plant height. Sarpan White × Bagalkot Local exhibited a significant positive *sca* effect for leaf area. For a number of branches, Sarpan Yellow × Bagalkot Local reported significant positive *sca* effects, this indicates non additive gene are responsible.

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