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Evaluation of chrysanthemum (*Dendranthema grandiflora* Tzvelev) genotypes for morphological and yield traits during different seasons

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Abstract

A field experiment was carried out to study the performance of chrysanthemum genotypes which suitable for cultivation in different seasons (*Kharif*, *rabi* and summer). The experiment was laid out in Randomized Block Design with fifty new genotypes in two replications at college of horticulture, Bengaluru. Based on the evaluation of various vegetative and yield parameters, the results revealed that plant height was found highest in cv. Cream white (55.32 cm) and HCC-1 (50.46 cm) and minimum was found in cv. Arka Pink Star (24.12 cm). Highest number of primary and secondary branches was found in cv. Poornima Yellow (17.37) and NBRI Little Pink (30.30). Maximum East-West and North-South direction plant spread was obtained in cv. Ruby Red (47.82 cm) and cv. IIHR RC-1 (44.91 cm). Number of flowers per plant was found highest in cv. Cream White (183.50) whereas, minimum was found in NBRI Little Orange (112.73). Maximum flower yield per plant was obtained in Scent White (424.56 g) followed by Poornima White (403.50 g), Aishwarya-1 (389.03 g) and Cream White (389.71 g).

Keywords: Chrysanthemum, genotypes, seasons, evaluation, growth and yield

Introduction

Chrysanthemum (*Dendranthema grandiflora* Tzvelev) is one of the most widely cultivated herbaceous perennial flowering plants belonging to family Asteraceae. It is commonly known as Autumn Queen or Queen of East, and is extensively grown all over the world for its beautiful, charming flowers having excellent vase life. It is one of the most widely cultivated garden flowers with diverse and beautiful range of colours, shades, widely variable flower shapes and range of height (Swaroop *et al.*, 2008) ^[46]. These characters make it highly suitable for pot culture, bedding purposes and for production of loose flowers for use in garland making, in worship and for decoration purposes. It also produces long, sturdy stems with good keeping quality, thus making it most suitable for cut-flower and exhibition purposes. Loose flower types are more popular in India for as these are used for making venis, garlands, bouquets and for religious offerings. Though a large number of chrysanthemum varieties are available in the market, novelty in commercial traits like flower colour, shape, size, growth habit, post-harvest life of the flower, *etc.*, are always valued and preferred by the consumer. There is a perpetual demand for superior genotypes.

The variations among Chrysanthemum varieties are huge in response to environment particularly temperature. The factors accounting for variation in growth and yield of crop plants are of very complex nature. Its growth and yield are known to be influenced by the environment and the genetic potential to a great extent. However, the genetic makeup of any crop can be exploited only when they are subjected to favorable environmental conditions. Therefore, in any crop plant information on genetic characters particularly which those contribute to economic characters would be very useful in planning breeding program leading to effective selection. Various biometrical techniques have been developed to know the genetic architecture of quantitative characters. The purpose of this study is to investigate and evaluate different genotype for various characters and select the best suitable genotypes.

Materials and Methods

The experiment was conducted to study performance of chrysanthemum (*Dendranthema grandiflora* Tzvelev) genotypes for vegetative traits during different seasons (*kharif*, *rabi* and

summer). The experiment comprised of fifty (Figure 1) chrysanthemum genotypes such as., Sapna, Arka Chandrika, Red Gold, White Star, Aishwarya-1, HCC-1, N-9, NBRI Little Pink, HYDC-7, Hossur, Winter Queen, Ruby Red, Scent White, Haldigatti, Aparajitha, Lalima, Rajat, Scent Yellow, Poornima White, Marigold, Poornima Yellow, Ratlam Selection, Dalore, Dolley Orange, Yellow Anemone, NBRI Little Orange, Corcum Small, Karnool Yellow, Thanu White, IIHR RC-1, Arka Kirti, Punjab Gold, Arka Pink Star, Vijay Kiran, Agnipath, Yellow Delight, Kaveri Orange, Bidhan Mum, Mallika Yellow, Co-1, B47/101, Airth-2, Jyostia, C6-11, Kalpana, Yellow Spoon, Yellow Gold, Thanu Yellow, Kaveri Pink and Cream White.

The genotypes were evaluated in Randomized Complete Block Design with two replications at College of Horticulture, Bengaluru. The plants were planted at a spacing of 60 X 45 cm and all the recommended cultural practices were followed. Five competitive plants were tagged at random in each treatment in each replication for recording detailed observation and the data were recorded for quantitative and qualitative characters *viz.*, plant height (cm), number of primary branches, number of secondary branches, plant spread (E-W) (cm), plant spread (N-S) (cm), days to first flower bud initiation, duration of flowering (days), number of flowers per plant, yield/plant (g) and flower yield per ha (g). In all the varieties/genotypes of chrysanthemum, the phenotypic expression of a character is mainly governed by the genetic make-up of the plant, the environment in which it is grown and the interaction between the genotype and environment. As a result, genotypes which perform well in one region may not perform same in other regions. Hence, it is necessary to assess the suitability of different chrysanthemum genotypes for successful cultivation through different seasons.

Results and Discussion

The plant height is an important growth related morphological character of plants. It is one of the essential criteria for screening of chrysanthemum varieties (Thiripurasundari *et al.*, 2021) [47]. At 90 days after planting tallest plant of 55.32 cm was obtained in cv. Cream White which was followed by cv. HCC-1 (50.46 cm) (Table 1) and it was lowest in cv. Arka Pink Star (24.72 cm). This variation in plant height expressed by different genotypes might be due to varietal characters responsible by a gene. As a genetically controlled factor, reported by Kanamadi and Patil (1993) [11]; Barigidad and Patil (1992) [3]; Singh *et al.* (2019) [44] in chrysanthemum. Performance of genotypes is also influenced by agro-climatic factors. The variations among chrysanthemum varieties are large in response to environment particularly temperature and the interaction between temperature and cultivar occur for every developmental trait. Similar findings are obtained by Pleog and Hauvelink, (2006) [32]. These results are in accordance with the findings of Uddin *et al.* (2013) [48] in chrysanthemum where increase in plant height was associated with rapid meristematic activity, probably due to rapid cell division and elongation during the tender growth period. This variation in plant height among various genotypes may be due to the hereditary traits as all the plants were given similar cultural practices under same environmental conditions. Similar variation in plant height among varieties was also observed in chrysanthemum by Baskaran *et al.* (2004) [16]; Kim *et al.* (2014) [12]; Swaroop *et al.* (2008) [46]; Singh *et al.* (2008) [42]; Kumar and Chattopadhyay (2002) [14]; Laxmi *et al.*, (2008) [19]; Palai

(2009) [28]; Banerji *et al.* (2012) [2]; Kumar *et al.* (2016) [45]; Punetha *et al.* (2011) [34]; Parmar *et al.* (2019) [29]; Madam *et al.* (2016) [20]; Behera *et al.* (2002) [5]; Singh *et al.* (2019) [44] Similar variation in plant height among varieties was also observed in marigold (Raghuvanshi *et al.*, 2011) [35] and in rose by Hussain and Khan (2004) [8].

Significant differences were also observed among the genotypes studied with respect to number of primary branches (Table 1). At 90 days after planting cv. Poornima Yellow (17.37) recorded maximum number of branches per plant followed by cv. Yellow Anemone (15.60) and it was lowest in cv. Ratlam Selection (8.30). The maximum number of secondary branches (Table 1) recorded in the cv. NBRI Little Pink (30.30) Whereas it was minimum (18.00) in the cv. Hossur. Difference in number of primary and secondary branches produced per plant among the genotypes could be due to the influence of genetical make up of chrysanthemum genotypes. Similar results were reported by Laxmi *et al.* (2008) [19] in chrysanthemum where genotypes having different capacity of storing reserved food materials resulting in plant vigour which might increase the primary branches. Similar variation for number of branches was also observed in China aster by Munikrishnappa *et al.* (2013) [23]; Kumar *et al.*, (2015) [18] in chrysanthemum and Shaikat *et al.*, (2013) [40] in gladiolus. Variation in number of branches may also be attributed to the soil and climatic conditions prevailing in the area that influenced the genotypes of dahlia (Bajaraya *et al.*, 2018) [1]. Among the different seasons of evolution of genotypes, the chrysanthemum genotypes which grown in summer season crop recorded the maximum number of primary branches per plant compared to other two seasons. This might be due to chrysanthemum requires long day for vegetative growth as it is available during summer season with day length of 3.10-8.20 hrs. with a minimum temperature of 28.30-33.30 °C and relative humidity of 81.00-87.00 per cent. This is in conformity with the studies of Negi *et al.* (2020) [26] and Nozaki and Fukai (2008) [27] in chrysanthemum.

Different varieties of chrysanthemum exhibited significant variation for plant spread (E-W) (Table 2). At 90 days after planting cv. Ruby Red (47.82 cm) followed by IIHR RC-1 (42.63 cm) exhibited maximum plant spread and minimum in the cv. Yellow Gold (26.90 and 25.77 cm) in both *kharif* season and pooled mean respectively. At 90 days after planting cv. IIHR RC-1 (44.91 cm) recorded maximum plant spread in north to south direction (Table 2) which was on par with cv. Yellow Delight (44.39 cm) and it was minimum in cv. Kaveri Orange (31.11 cm). Among the different seasons, crop raised during *kharif* season recorded the maximum plant spread (E-W) and (N-S) which might be due to optimum availability ambient temperature during the growth period around 27.30-29.50 °C which delays the flowering and improves the vegetative growth and sunshine hours of 3.40-6.70 hrs. This was in accordance with the study conducted by Nozaki and Fukai (2008) [27] and Nakano *et al.* (2020) [25] in chrysanthemum. Plant spread differed significantly among all the genotypes which might be due to genetic makeup of the varieties and development of more number secondary branches in the genotypes thereby it increases the plant spread (E-W). Similar results were also reported by Poonam and Kumar (2007) [33] in chrysanthemum. Increase in plant spread might be due to the production of more number of lateral branches per plant and by the genetic nature of the genotype and also its wide adaptability to the prevailing environmental conditions. Similar trend of result was also observed earlier by Rajiv *et*

al. (2007) ^[36]; Parul *et al.* (2011) ^[30] and Suvija *et al.* (2016) ^[45] in chrysanthemum. Similar results also obtained by

Singh *et al.* (2017) ^[43] and Parmar *et al.* (2019) ^[29] in chrysanthemum.



Fig 1a: Chrysanthemum genotypes used in the experiment



Fig 1b: Chrysanthemum genotypes used in the experiment



Scent White

Haldigatti

Aparajitha



Lalima

Rajat

Scent Yellow

Fig 1c: Chrysanthemum genotypes used in the experiment



Poornima White

Marigold

Poornima Yellow



Ratlam Selection

Dalore

Dolley Orange

Fig 1d: Chrysanthemum genotypes used in the experiment



Yellow Anemone

NBRI Little Orange

Corcorm Small



Karnool Yellow

Thanu white

IIHR RC-1

Fig 1e: Chrysanthemum genotypes used in the experiment



Arka Kirti

Punjab Gold

Arka Pink Star



Vijay Kiran

Agnipath

Yellow Delight

Fig 1f: Chrysanthemum genotypes used in the experiment



Kaveri Orange

Bidhan Mum

Mallika Yellow



CO-1

B47/101

Airth-2

Fig 1g: Chrysanthemum genotypes used in the experiment



Jyotsia

C6-11

Kalpana



Yellow Spoon

Yellow Gold

Thanu Yellow

Fig 1h: Chrysanthemum genotypes used in the experiment



Kaveri Pink

Cream White

Fig 1i: Chrysanthemum genotypes used in experiment**Table 1:** Plant height (cm), number of primary and secondary branches per plant at (90 days) different growth stages of chrysanthemum genotypes

Sl. No.	Genotypes	Plant height (cm)				Number of primary branches per plant				Number of secondary branches per plant			
		Kharif	Rabi	Summer	Pooled mean	Kharif	Rabi	Summer	Pooled mean	Kharif	Rabi	Summer	Pooled mean
1.	Sapna	37.95	29.41	41.15	36.17	14.10	5.80	15.00	11.63	24.30	14.10	33.20	23.87
2.	Arka Chandrika	36.69	44.46	36.12	39.09	17.70	5.90	14.00	12.53	35.20	18.20	26.80	26.73
3.	Red Gold	43.60	29.76	44.59	39.32	11.30	7.10	11.00	9.80	35.00	16.80	27.00	26.27
4.	White Star	49.77	28.65	40.57	39.66	15.00	7.40	16.30	12.90	34.20	19.30	29.30	27.60
5.	Aishwarya-1	35.91	35.85	33.63	35.13	18.80	8.20	17.00	14.67	25.90	19.70	33.70	26.43
6.	HCC-1	48.68	51.02	51.68	50.46	18.00	7.80	11.60	12.47	30.90	19.00	24.40	24.77
7.	N-9	39.84	31.41	35.94	35.73	11.70	8.40	10.30	10.13	20.50	18.30	24.30	21.03
8.	NBRI Little Pink	42.65	23.62	39.67	35.31	16.60	8.80	19.90	15.10	34.40	19.50	37.00	30.30
9.	HYDC-7	55.77	30.80	54.43	47.00	24.90	7.00	14.20	15.37	31.80	19.30	30.90	27.33
10.	Hossur	53.65	33.40	49.33	45.46	14.30	6.80	10.10	10.40	22.00	14.20	17.80	18.00
11.	Winter Queen	45.87	33.10	43.67	40.88	9.70	7.20	8.50	8.47	17.60	15.20	24.30	19.03
12.	Ruby Red	44.39	28.96	48.80	40.72	18.80	6.30	17.30	14.13	33.30	19.50	29.80	27.53
13.	Scent White	42.03	30.25	50.35	40.88	13.00	8.60	16.20	12.60	28.50	18.60	35.50	27.53
14.	Haldigatti	38.39	29.03	40.81	36.08	17.40	6.50	16.30	13.40	23.40	16.40	30.50	23.43
15.	Aparajitha	43.58	30.97	43.91	39.49	13.60	10.50	16.20	13.43	22.40	22.10	30.50	25.00
16.	Lalima	37.79	38.77	36.76	37.77	17.80	7.50	14.10	13.13	26.60	19.40	30.00	25.33
17.	Rajat	46.51	33.79	42.17	40.82	16.40	6.30	16.20	12.97	28.50	17.80	31.80	26.03
18.	Scent Yellow	42.76	30.40	35.62	36.26	17.30	6.70	11.00	11.67	27.20	16.10	29.20	24.17
19.	Poornima White	42.06	23.12	40.62	35.27	16.00	7.00	16.30	13.10	32.70	16.90	29.70	26.43
20.	Marigold	44.89	22.62	43.50	37.00	16.90	8.70	15.70	13.77	37.70	19.50	30.50	29.23
21.	Poornima Yellow	50.98	33.86	47.37	44.07	27.10	5.70	19.30	17.37	36.70	15.00	33.10	28.27
22.	Ratlam Selection	43.89	25.96	42.36	37.40	11.80	5.10	8.00	8.30	21.00	13.70	21.40	18.70
23.	Dalore	40.57	21.33	37.13	33.01	13.50	6.50	12.30	10.77	36.60	14.30	28.60	26.50
24.	Dolley Orange	39.05	24.78	30.37	31.40	17.20	7.40	15.90	13.50	24.90	19.90	29.30	24.70
25.	Yellow Anemone	45.13	26.75	32.82	34.90	22.30	7.80	16.70	15.60	33.80	21.50	27.30	27.53
26.	NBRI Little Orange	45.09	28.31	41.68	38.36	11.30	6.20	8.30	8.60	22.70	16.70	19.50	18.97
27.	Corcum Small	29.93	19.07	31.77	26.92	14.20	7.20	10.20	10.53	28.60	16.70	18.90	21.40
28.	Karnool Yellow	39.70	22.55	40.03	34.09	16.90	6.80	14.90	12.87	34.20	18.50	30.40	27.70
29.	Thanu White	43.74	34.96	38.25	38.98	19.40	6.50	13.80	13.23	40.90	16.50	29.90	29.10
30.	IHR RC-1	43.04	25.05	38.63	35.57	21.60	7.00	16.60	15.07	38.30	19.90	26.90	28.37
31.	Arka Kirti	43.50	22.60	37.92	34.67	22.00	8.20	11.70	13.97	35.50	20.20	23.10	26.27
32.	Punjab Gold	45.88	25.95	43.09	38.31	15.00	6.00	11.10	10.70	30.00	16.40	23.80	23.40
33.	Arka Pink Star	28.07	18.64	27.45	24.72	16.80	8.80	15.10	13.57	31.80	18.10	28.40	26.10
34.	Vijay Kiran	35.21	27.68	27.11	30.00	20.30	7.70	15.00	14.33	28.20	18.80	28.00	23.00
35.	Agnipath	39.24	25.09	31.60	31.98	16.00	6.40	15.70	12.70	25.10	17.70	29.50	24.10
36.	Yellow Delight	50.73	27.54	46.69	41.65	19.90	5.40	18.00	14.43	37.80	16.10	28.30	27.40
37.	Kaveri Orange	33.07	21.14	37.16	30.46	11.60	5.40	11.30	9.43	28.70	15.30	23.20	22.40
38.	Bidhan Mum	45.85	23.42	47.07	38.78	10.90	6.40	12.30	9.87	21.00	16.00	29.50	22.17
39.	Mallika Yellow	38.25	29.32	29.90	32.49	15.60	7.70	13.30	12.20	22.90	18.90	28.50	23.43
40.	Co-1	42.15	21.41	37.99	33.85	16.40	7.30	10.60	11.43	25.20	18.70	28.70	24.20
41.	B47/101	52.59	26.37	43.00	40.65	16.60	5.80	13.30	11.90	21.90	22.70	28.60	21.07
42.	Airth-2	33.05	20.67	38.06	30.59	10.90	7.40	11.10	9.80	19.60	17.90	37.70	25.07
43.	Jyostia	33.30	20.35	25.56	26.40	11.10	5.60	11.40	9.37	23.20	14.00	28.90	22.03
44.	C6-11	46.50	30.08	40.96	39.18	13.10	6.10	12.10	10.43	25.40	16.90	25.60	22.63
45.	Kalpana	38.85	18.32	33.26	30.14	16.30	7.60	14.10	12.67	35.40	17.10	29.40	27.30

46.	Yellow Spoon	46.30	20.71	42.27	36.43	16.20	6.00	12.20	11.47	23.40	16.10	25.20	21.57
47.	Yellow Gold	45.21	26.14	46.89	39.41	11.30	6.20	14.70	10.73	28.00	15.20	35.00	26.07
48.	Thanu Yellow	45.91	22.72	33.08	33.90	13.40	7.50	12.70	11.20	26.50	17.10	26.80	23.47
49.	Kaveri Pink	44.45	24.91	40.95	36.77	15.30	7.20	13.90	12.13	25.40	17.60	27.40	23.47
50.	Cream White	86.36	24.89	54.71	55.32	17.80	7.00	11.60	12.13	29.70	17.60	26.50	24.60
	S. Em. \pm	1.22	2.12	1.37	1.01	1.00	1.01	0.52	0.52	2.23	1.81	0.72	1.12
	CD @ 5%	3.46	6.03	3.91	2.89	2.85	2.88	1.48	1.50	6.35	5.15	2.05	3.2
	CV (%)	13.98	10.88	14.87	13.89	8.87	18.29	5.39	6.10	11.03	NS	13.63	6.43

Table 2: Plant spread (EW & NS direction) (cm) (90 days) and days to flower bud initiation at different growth stages of chrysanthemum genotypes

Sl. No.	Genotypes	Plant spread (East-West direction) (cm)				Plant spread (North-South direction) (cm)				Days to flower bud initiation			
		Kharif	Rabi	Summer	Pooled mean	Kharif	Rabi	Summer	Pooled mean	Kharif	Rabi	Summer	Pooled mean
1.	Sapna	29.60	25.58	34.01	29.73	36.71	26.89	36.58	33.39	59.10	52.00	60.10	57.07
2.	Arka Chandrika	38.45	26.81	40.21	35.16	40.52	28.04	37.63	35.40	55.40	52.60	55.80	54.60
3.	Red Gold	35.05	26.61	35.78	32.48	39.90	26.02	39.94	35.29	66.50	58.60	64.50	63.20
4.	White Star	39.67	21.17	43.46	34.77	42.76	24.99	46.71	38.15	61.50	50.20	76.90	62.87
5.	Aishwarya-1	50.55	27.48	44.98	41.00	55.84	22.99	43.54	40.79	75.40	54.10	66.10	65.20
6.	HCC-1	52.14	30.28	37.14	39.85	41.03	33.06	44.93	39.67	64.80	50.50	61.80	59.03
7.	N-9	36.10	31.67	36.58	34.78	41.71	25.66	39.15	35.51	73.20	52.60	74.80	66.87
8.	NBRI Little Pink	38.88	27.53	40.63	35.68	38.54	25.56	39.28	34.46	51.00	64.70	53.20	56.30
9.	HYDC-7	36.00	27.05	41.42	34.82	46.32	24.84	41.42	37.53	48.40	53.70	51.40	51.77
10.	Hossur	36.62	30.08	37.54	34.75	41.01	31.41	35.60	36.01	72.90	61.80	84.80	73.17
11.	Winter Queen	41.30	25.94	40.64	35.96	37.16	31.68	37.71	35.52	70.60	59.50	74.40	68.17
12.	Ruby Red	59.89	26.31	57.25	47.82	36.50	25.21	48.45	36.72	59.20	52.20	69.20	60.20
13.	Scent White	29.45	36.21	39.73	35.13	36.17	32.76	43.53	37.49	54.70	64.20	52.20	57.03
14.	Haldigatti	30.54	27.64	49.20	35.79	35.10	31.95	50.56	39.20	62.00	57.00	62.60	60.53
15.	Aparajitha	42.91	28.30	43.17	38.13	46.86	32.03	41.73	40.21	74.70	51.40	73.40	66.50
16.	Lalima	43.31	27.67	46.44	39.14	41.21	32.46	43.13	38.93	64.00	85.70	63.40	71.03
17.	Rajat	49.10	29.98	48.04	42.37	48.27	28.84	44.00	40.37	66.30	66.60	68.00	66.97
18.	Scent Yellow	43.83	31.29	40.37	38.50	51.96	27.89	43.28	41.04	78.40	57.20	79.50	71.70
19.	Poornima White	49.42	30.26	42.21	40.63	52.46	25.77	40.41	39.55	59.30	53.70	61.30	58.10
20.	Marigold	33.22	24.23	30.74	29.40	34.21	28.57	31.50	31.43	54.80	55.50	25.20	45.17
21.	Poornima Yellow	47.49	26.63	44.54	39.55	42.65	23.98	42.17	36.27	76.00	50.60	73.70	66.77
22.	Ratlam Selection	40.02	22.15	28.81	30.33	42.38	24.12	31.66	32.05	54.40	57.30	55.50	55.73
23.	Dalore	36.02	23.68	35.27	31.66	37.21	23.17	39.66	33.35	54.70	49.70	52.90	52.43
24.	Dolley Orange	37.96	22.62	35.34	31.97	40.68	22.96	40.02	34.42	73.40	58.30	73.90	68.53
25.	Yellow Anemone	40.82	24.27	29.38	31.49	46.23	30.65	40.12	39.00	69.40	51.90	73.80	65.03
26.	NBRI Little Orange	42.30	21.67	40.31	34.76	34.25	27.86	32.55	31.55	58.20	50.70	55.90	54.93
27.	Corcum Small	37.73	22.43	32.76	30.97	41.72	22.87	36.81	33.80	63.20	57.50	67.90	62.87
28.	Karnool Yellow	41.66	23.59	37.65	34.30	44.08	26.72	37.10	35.97	73.00	54.10	77.40	68.17
29.	Thanu White	44.17	25.62	38.72	36.17	43.21	24.58	36.93	34.91	69.30	58.80	74.10	67.40
30.	IHR RC-1	51.17	20.35	56.38	42.63	57.07	27.09	50.57	44.91	77.10	48.50	74.20	66.60
31.	Arka Kirti	33.82	28.74	30.08	30.88	33.29	28.17	26.93	29.46	66.00	52.40	68.20	62.20
32.	Punjab Gold	46.11	25.66	44.14	38.64	54.62	25.83	52.31	44.25	74.00	54.10	77.80	68.63
33.	Arka Pink Star	37.05	26.22	41.96	35.08	41.92	27.65	37.99	35.85	45.50	59.70	49.80	51.67
34.	Vijay Kiran	42.16	30.02	41.50	37.89	38.00	28.63	37.12	34.58	76.60	64.60	80.60	73.93
35.	Agnipath	35.75	25.04	36.56	32.45	39.50	26.95	36.49	34.31	90.40	48.00	94.80	77.73
36.	Yellow Delight	41.71	31.47	42.38	38.52	50.92	29.47	52.77	44.39	64.60	53.90	63.20	60.57
37.	Kaveri Orange	30.41	23.19	35.22	29.61	30.73	22.82	39.78	31.11	79.80	55.00	76.60	70.47
38.	Bidhan Mum	42.71	28.07	42.94	37.91	45.27	26.91	42.28	38.15	56.40	50.50	65.70	57.53
39.	Mallika Yellow	36.87	30.55	34.93	34.12	39.65	33.23	37.57	36.82	64.80	61.50	68.50	64.93
40.	Co-1	34.44	24.78	28.35	29.19	42.02	25.69	34.55	34.09	76.00	64.60	76.70	72.43
41.	B47/101	37.22	22.66	29.46	29.78	40.51	25.82	36.81	34.38	67.50	54.20	69.10	63.60
42.	Airth-2	42.15	28.46	41.78	37.46	45.10	22.64	41.76	36.50	66.90	51.20	62.80	60.30
43.	Jyostia	35.40	20.19	36.42	30.67	39.30	25.83	30.46	31.86	70.70	60.00	66.60	65.77
44.	C6-11	47.65	22.43	51.15	40.41	53.30	24.90	53.59	43.93	58.10	66.00	58.40	60.83
45.	Kalpana	33.60	22.63	35.61	30.61	35.95	24.71	34.78	31.81	57.60	69.50	51.80	59.37
46.	Yellow Spoon	42.45	22.83	38.26	34.51	48.50	23.88	42.17	38.18	68.20	58.80	71.60	66.20
47.	Yellow Gold	25.77	23.89	31.05	26.90	41.32	25.12	44.89	37.11	88.60	58.60	88.00	78.40
48.	Thanu Yellow	34.60	21.36	26.79	27.58	39.40	23.26	33.57	32.08	65.90	60.50	69.70	65.37
49.	Kaveri Pink	39.70	25.75	42.54	36.00	43.85	26.09	37.88	35.94	62.60	53.60	61.60	59.27
50.	Cream White	41.10	22.09	42.69	35.29	43.00	23.85	37.62	34.82	73.80	45.20	80.50	66.50
	S. Em. \pm	2.72	3.01	1.10	1.37	1.72	2.74	1.50	1.14	1.91	4.20	1.89	1.72
	CD @ 5%	7.74	8.57	3.14	3.89	4.90	7.80	4.26	3.24	5.43	11.94	5.37	4.90
	CV (%)	9.65	NS	13.98	5.52	5.75	NS	10.28	9.42	14.08	10.48	13.98	13.84

Table 3: Number of flowers per plant and duration of flowering in different chrysanthemum genotypes

Sl. No.	Genotypes	Number of flowers per plant				Duration of flowering			
		Kharif	Rabi	Summer	Pooled mean	Kharif	Rabi	Summer	Pooled mean
1.	Sapna	175.20	126.50	177.70	136.53	38.50	19.60	38.20	32.10
2.	Arka Chandrika	102.40	131.70	111.40	113.10	34.40	26.20	43.30	34.63
3.	Red Gold	107.10	117.40	113.30	109.93	28.10	33.60	38.60	33.43
4.	White Star	117.20	113.10	126.20	117.83	43.60	21.80	43.60	36.33
5.	Aishwarya-1	125.50	129.20	123.50	138.00	77.20	33.30	56.50	55.67
6.	HCC-1	138.00	135.00	101.40	124.80	37.30	34.50	47.60	39.80
7.	N-9	243.30	121.00	253.30	170.60	31.90	27.20	45.10	34.73
8.	NBRI Little Pink	224.00	127.30	242.00	164.50	53.10	18.30	40.60	37.33
9.	HYDC-7	122.90	122.00	131.50	125.47	56.50	35.00	45.40	45.63
10.	Hossur	137.70	160.60	118.20	138.83	41.50	38.40	43.30	41.07
11.	Winter Queen	159.70	122.30	171.40	151.13	45.40	37.30	66.20	49.63
12.	Ruby Red	243.40	129.00	251.40	173.43	56.40	24.90	47.10	42.80
13.	Scent White	231.90	116.80	238.80	162.10	63.80	38.70	63.50	55.33
14.	Haldigatti	207.20	119.80	212.50	145.40	35.20	32.70	44.80	37.57
15.	Aparajitha	141.60	124.30	148.80	138.23	45.90	40.60	56.10	47.53
16.	Lalima	133.80	132.10	136.80	134.23	45.40	22.50	47.30	38.40
17.	Rajat	139.70	125.50	138.90	134.70	42.70	33.00	55.10	43.60
18.	Scent Yellow	155.70	156.20	167.90	159.93	46.60	38.50	41.30	42.13
19.	Poornima White	232.70	119.10	251.20	167.47	55.50	37.10	53.80	48.80
20.	Marigold	129.10	133.10	136.70	132.97	43.10	18.70	57.00	39.60
21.	Poornima Yellow	185.50	132.90	188.70	152.37	56.80	27.30	47.90	44.00
22.	Ratlam Selection	175.90	144.60	177.60	149.37	32.60	22.90	44.20	33.23
23.	Dalore	215.60	124.70	229.20	156.50	40.50	17.80	54.00	37.43
24.	Dolley Orange	180.80	122.80	250.60	168.07	33.00	23.60	45.90	34.17
25.	Yellow Anemone	243.40	119.70	260.90	174.60	38.70	31.10	47.40	39.07
26.	NBRI Little Orange	94.80	143.40	100.00	112.73	34.10	33.00	35.90	34.33
27.	Corcum Small	137.80	88.70	157.00	127.83	41.00	23.20	66.10	43.43
28.	Karnool Yellow	99.00	163.20	129.30	130.50	35.20	29.70	44.20	36.37
29.	Thanu White	137.80	149.50	133.70	140.33	41.70	20.30	55.70	39.23
30.	IIHR RC-1	140.40	199.70	141.40	160.50	47.90	26.80	47.70	40.80
31.	Arka Kirti	211.10	129.00	219.90	153.40	39.20	30.40	48.00	39.20
32.	Punjab Gold	243.80	134.00	253.10	176.97	35.90	27.60	43.50	35.67
33.	Arka Pink Star	261.80	145.50	249.70	173.67	44.80	26.20	55.20	42.07
34.	Vijay Kiran	263.80	122.40	251.30	179.17	50.10	29.40	71.30	50.27
35.	Agnipath	222.00	148.00	225.50	181.47	44.10	23.10	70.60	45.93
36.	Yellow Delight	230.60	130.50	261.40	174.17	51.60	32.10	54.90	46.20
37.	Kaveri Orange	247.40	135.90	257.90	180.40	42.50	39.40	56.30	46.07
38.	Bidhan Mum	215.70	144.20	233.10	164.33	38.10	24.40	58.60	40.37
39.	Mallika Yellow	223.80	123.60	228.80	158.73	39.00	22.90	49.20	37.03
40.	Co-1	146.40	127.30	155.20	142.97	51.90	32.30	56.00	46.73
41.	B47/101	211.80	116.70	212.90	146.50	43.30	32.20	49.10	41.53
42.	Airth-2	206.80	131.70	202.10	146.87	52.90	34.60	51.00	46.17
43.	Jyostia	111.80	145.00	118.70	125.17	42.20	31.30	56.20	43.23
44.	C6-11	215.10	166.50	227.10	169.57	46.50	33.30	50.60	43.47
45.	Kalpana	111.60	135.80	125.30	124.23	38.20	25.30	49.70	37.73
46.	Yellow Spoon	206.60	140.30	206.30	151.07	56.10	31.90	51.60	46.53
47.	Yellow Gold	255.40	126.40	258.60	170.13	45.10	32.70	50.40	42.73
48.	Thanu Yellow	228.40	135.20	237.50	167.03	36.80	38.40	44.20	39.80
49.	Kaveri Pink	202.50	168.50	207.70	159.57	61.00	39.20	43.40	47.87
50.	Cream White	250.60	144.50	255.50	183.50	65.20	36.20	52.80	51.40
	S. Em. \pm	12.18	4.61	13.59	4.40	1.05	0.28	0.74	0.41
	CD @ 5%	34.61	13.10	38.63	12.51	2.99	0.79	2.10	1.17
	CV (%)	9.39	4.86	10.07	4.11	13.24	9.33	2.07	11.6

Table 4: Flower yield per plant and hectare in different genotypes of chrysanthemum

Sl. No.	Genotypes	Yield/ plant (g)				Yield/ha (ton)			
		Kharif	Rabi	Summer	Pooled mean	Kharif	Rabi	Summer	Pooled mean
1.	Sapna	215.99	170.40	304.59	230.33	8.00	6.31	11.28	8.53
2.	Arka Chandrika	201.89	186.93	324.49	237.77	7.48	6.92	12.02	8.81
3.	Red Gold	304.49	188.90	371.91	288.43	11.28	7.00	13.77	10.68
4.	White Star	293.07	208.73	294.27	265.36	10.85	7.73	10.90	9.83
5.	Aishwarya-1	507.02	213.03	447.04	389.03	18.78	7.89	16.56	14.41
6.	HCC-1	265.48	199.22	556.23	340.31	9.83	7.38	20.60	12.60
7.	N-9	268.94	159.01	299.22	242.39	9.96	5.89	11.08	8.98
8.	NBRI Little Pink	317.23	161.12	204.46	227.60	11.75	5.97	7.57	8.43
9.	HYDC-7	225.12	154.29	491.97	290.46	8.34	5.71	18.22	10.76
10.	Hossur	224.83	161.96	257.34	214.71	8.33	6.00	9.53	7.95
11.	Winter Queen	277.45	151.68	227.34	218.82	10.28	5.62	8.42	8.10
12.	Ruby Red	270.11	168.88	163.36	200.78	10.00	6.25	6.05	7.44
13.	Scent White	358.49	142.72	772.47	424.56	13.28	5.29	28.61	15.72
14.	Haldigatti	304.50	151.62	152.05	202.72	11.28	5.62	5.63	7.51
15.	Aparajitha	237.29	140.98	375.00	251.09	8.79	5.22	13.89	9.30
16.	Lalima	254.69	151.86	113.18	173.24	9.43	5.62	4.19	6.42
17.	Rajat	184.51	154.89	362.33	233.91	6.83	5.74	13.42	8.66
18.	Scent Yellow	286.87	169.02	630.10	362.00	10.62	6.26	23.34	13.41
19.	Poornima White	504.53	157.24	548.72	403.50	18.69	5.82	20.32	14.94
20.	Marigold	303.72	173.72	286.91	254.78	11.25	6.43	10.63	9.44
21.	Poornima Yellow	257.81	180.31	389.03	275.72	9.55	6.68	14.41	10.21
22.	Ratlam Selection	264.79	142.52	222.45	209.92	9.81	5.28	8.24	7.77
23.	Dalore	240.41	175.59	144.13	186.71	8.90	6.50	5.34	6.92
24.	Dolley Orange	253.02	156.88	367.67	259.19	9.37	5.81	13.62	9.60
25.	Yellow Anemone	249.19	170.04	370.75	263.33	9.23	6.30	13.73	9.75
26.	NBRI Little Orange	217.88	197.10	236.34	217.11	8.07	7.30	8.75	8.04
27.	Corcum Small	250.77	158.94	316.73	242.15	9.29	5.89	11.73	8.97
28.	Karnool Yellow	188.69	188.33	388.19	255.07	6.99	6.98	14.38	9.45
29.	Thanu White	211.48	188.27	276.20	225.32	7.83	6.97	10.23	8.35
30.	IHR RC-1	240.71	149.86	246.18	212.25	8.92	5.55	9.12	7.86
31.	Arka Kirti	252.20	138.22	379.22	256.55	9.34	5.12	14.05	9.50
32.	Punjab Gold	257.31	152.63	275.79	228.58	9.53	5.65	10.21	8.47
33.	Arka Pink Star	261.80	154.84	322.41	246.35	9.70	5.73	11.94	9.12
34.	Vijay Kiran	250.61	177.98	387.41	272.00	9.28	6.59	14.35	10.07
35.	Agnipath	332.24	148.91	401.12	294.09	12.31	5.52	14.86	10.89
36.	Yellow Delight	235.67	184.16	351.99	257.27	8.73	6.82	13.04	9.53
37.	Kaveri Orange	339.90	191.04	530.30	353.75	12.59	7.08	19.64	13.10
38.	Bidhan Mum	287.55	198.49	373.68	286.57	10.65	7.35	13.84	10.61
39.	Mallika Yellow	260.93	177.87	254.66	231.15	9.66	6.59	9.43	8.56
40.	Co-1	245.48	158.56	231.52	211.85	9.09	5.87	8.57	7.85
41.	B47/101	257.03	178.98	476.05	304.02	9.52	6.63	17.63	11.26
42.	Airth-2	229.01	181.15	252.13	220.76	8.48	6.71	9.34	8.18
43.	Jyostia	267.44	169.51	314.53	250.49	9.91	6.28	11.65	9.28
44.	C6-11	244.09	159.37	485.09	296.18	9.04	5.90	17.97	10.97
45.	Kalpana	239.26	163.59	277.41	226.75	8.86	6.06	10.27	8.40
46.	Yellow Spoon	234.02	157.41	297.73	229.72	8.67	5.83	11.03	8.51
47.	Yellow Gold	234.49	148.52	361.52	248.18	8.68	5.50	13.39	9.19
48.	Thanu Yellow	241.29	179.42	214.77	211.83	8.94	6.65	7.95	7.85
49.	Kaveri Pink	270.88	154.44	578.63	334.65	10.03	5.72	21.43	12.39
50.	Cream White	404.56	142.46	622.10	389.71	14.98	5.28	23.04	14.43
	S. Em. \pm	24.61	17.54	25.56	13.95	0.91	0.64	0.94	0.51
	CD@5%	69.94	49.86	72.63	39.64	2.59	1.84	2.69	1.46
	CV (%)	12.87	14.78	10.31	7.50	12.86	14.78	10.30	7.50

Days to flower bud initiation of chrysanthemum genotypes differed significantly in all the three seasons and for pooled mean (Table 2). From the pooled mean earliest flower bud initiation was exhibited by the cv. Arka Pink Star (51.67 days) which was followed by cv. HYDC-7 (51.77 days) and it was delayed in cv. Yellow Gold (78.40 days). During *kharif* season and summer season early flower bud initiation was recorded in cv. Arka Pink Star (45.50 and 49.80 days respectively) which was followed by HYDC-7 (48.40 and 51.40 days respectively), whereas it was delayed in cv.

Agnipath (90.40 and 94.80 days respectively). Days to flower bud initiation among different genotypes will differ among varieties and it might be due to presence of sufficient genetic variability existing among genotypes. Early or delay in flowering might also be genetically controlled characters in the varieties and it as stated by Behera *et al.* (2002)^[5] in chrysanthemum. The cultivar being an early bloomer or late bloomer seems to be the inherent varietal character and genetic nature of the plant. Similar such results were reported by Mishra and Saini (1997)^[22] in dahlia. Similar

findings were also obtained by Joshi *et al.* (2010)^[10]; Suvija *et al.* (2016)^[45]; Rao and Pratap (2006)^[38]; Rajiv *et al.* (2007)^[36]; Kishan *et al.* (2008)^[13] and Singh *et al.* (2008)^[42] in chrysanthemum. Among different seasons, rabi season recorded the earliest flowering compared to rest of the seasons. This seasonal variation in days to bud initiation might also be due to naturally available short-day condition with shorter sunshine hours (4.60 hrs.) during vegetative growth, temperature ranged between (13.50-27.70 °C), relative humidity (83.00-90%). Delayed flowering during summer and kharif season might also because of long photoperiod exposure (8.40 and 6.70 hrs. respectively) might have resulted from interference with carbohydrate and florigene movement to the receptive site, production of transmissible inhibitor and production of a substance which acts antagonistically to the flowering hormone at the apex under long day condition. These results are in accordance with Palai (2009)^[28] in chrysanthemum where photoperiod exposure might have resulted from interference with carbohydrate and florigene movement to the receptive site, production of transmissible inhibitor and production of a substance which acts antagonistically to the flowering hormone at the apex under long day condition.

The maximum number of flowers per plant was recorded from the pooled mean the cv. Cream White (183.50) recorded the maximum number of flowers per plant (Table 3) which was on par with cv. Agnipath (181.47) and it was lowest in the cv. NBRI Little Orange (112.73). The number of flowers produced per plant may be directly related to increase in plant height, more number of branches per plant, greater plant spread and increased number of leaves per plant and accumulation of more photosynthates, thereby leading to the production of more number of flowers. The similar results also were observed by Parul *et al.* (2011)^[30]; Dhanumjaya and Sushma (2014)^[7]; Uddin *et al.* (2015)^[9]; Chezhian *et al.*, 1985; Suvija *et al.* (2016)^[45] in chrysanthemum and in gerbera (Mahmood *et al.*, 2013)^[21]. From the pooled mean cv. Aishwarya-1 (55.67 days) recorded maximum duration of flowering which was on par with cv. Scent White (55.33 days) (Table 3) and it was minimum in cv. Sapna (32.10 days). The variation in flowering duration among the varieties might attributed to genotype of the plant, environmental influence and other crop management practices. Similar variation in flowering duration among the genotypes have also been reported in chrysanthemum under different environmental conditions (Lakshmi *et al.*, 2008; Kumar *et al.*, 2014 and Suvija *et al.*, 2016)^[41, 17, 45]. Similar results for variation in flowering duration among the genotypes have also been reported in chrysanthemum under different environmental conditions by Swaroop *et al.* (2008)^[46], Singh *et al.* (2008)^[42] and Rao and Pratap (2006)^[38].

Among the chrysanthemum genotypes from the pooled mean, cv. Scent White (424.56 g) recorded the highest flower yield/plant which was on par with Poornima White (403.50 g), Cream White (389.71 g) and cv. Aishwarya (389.03 g) whereas, minimum was exhibited by the cv. Lalima (173.24 g). Flower yield/ha showed similar trend where cv. Scent White (15.72 t/ha) (Table 4) recorded the highest yield/ha and lowest in cv. Lalima (6.42 t/ha). The difference in the flower yield per plant may be due to the varietal character, habitat type and genetic makeup of the varieties. Variation in flower yield per plant may be due to weight of flowers per plant directly correlated with number

of flowers per plant Similar results were recorded in chrysanthemum by Siddiqua *et al.* (2018)^[41]. Higher yield might be due to increase in morphological parameters like plant height, number of leaves and leaf area, plant spread and number of branches which might have contributed in production of more photosynthates resulting in production of more number of flowers per plant which might have contributed in production of more photosynthates resulting in greater accumulation of dry matter which in turn leads to production of more flower yield. Similar results are obtained in chrysanthemum by Jamaluddin *et al.* (2015)^[9]; Palai *et al.* (2018)^[28]; Sharma, (2014)^[39]; Ramzan *et al.* (2014)^[37]; Kumar *et al.* (2016)^[15] Munikrishnappa *et al.* (2013)^[23] in China aster. Similar findings reported by Patil (2001)^[31] in carnation and (Naik *et al.*, 2005) in marigold. Similar results were recorded in chrysanthemum by Thiripurasundari *et al.* (2021)^[47]; Suvija *et al.* (2016)^[45]. Higher yields were due to the greater number of flowers and heavier flowers. Several studies reported varietal differences grown in similar environments in number of flowers, flower weight and yield, and is genetically determined (Singh *et al.*, 2008; Swaroop *et al.*, 2008)^[42, 46]. The difference in yield may be due to the additive gene effect (Behera *et al.*, (2002)^[5]. Lakshmi *et al.* (2008)^[41] suggested that this character may be due to genetic behaviour of the genotype.

By combining all the seasons, cv. Cream White, Poornima Yellow, NBRI Little Pink, Ruby Red, IIHR RC-1 found best for growth parameters. The cv. Cream White, cv. Arka Pink Star, NBRI Little Orange, Aishwarya-1, Scent White, Winter Queen, Kaveri Pink, Yellow Anemone recorded superior for flowering and yield parameters.

Conclusion

In conclusion, the study underscores the significance of plant height as a crucial morphological indicator in chrysanthemum varieties, influencing screening processes. Variability in plant height among genotypes reflects underlying genetic factors, as reported by previous studies. Furthermore, environmental factors, particularly temperature, interact intricately with cultivars, impacting developmental traits. The observed variation in primary and secondary branches per plant can be attributed to genetic makeup, influencing plant vigor and branching patterns. Similarly, differences in plant spread are indicative of genetic variability and adaptability to environmental conditions. Flowering characteristics, such as days to flower bud initiation and duration, vary among genotypes and seasons, suggesting genetic control and environmental influences. Notably, flower yield per plant is influenced by morphological parameters like plant height, number of branches, and plant spread, highlighting their role in photosynthate production and subsequent flower yield. Overall, certain genotypes exhibit superior growth, flowering, and yield characteristics across seasons, indicating their potential suitability for cultivation.

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