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Effect of month of planting and spacing on growth and flower yield in chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. Marigold

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Abstract
A field experiment was conducted during *kharif*, 2018-19 and 2020-21 at the Horticulture Garden, Department of Horticulture, UAS, Raichur, Karnataka. The experiment was laid out in a split plot design with fifteen treatments including month of planting, spacing and their combination in three replications. The result emanated from the experiment significantly recorded maximum growth and flower yield parameters. Planting during second fortnight of august at the spacing of 45 cm × 45 cm (M_1S_3) recorded maximum plant height, number of secondary branches, stem girth, less days taken for flower bud initiation, more number of flowers per plant whereas, maximum flower yield per plot and flower yield per hectare was observed in the treatment of second fortnight of august transplanting with spacing of 30 cm × 30 cm (M_1S_2).

Keywords: Chrysanthemum, month of planting, spacing, growth and flower yield

Introduction
Chrysanthemum (*Dendranthema grandiflora* Tzvelev.) belongs to family Asteraceae, has tremendous popularity as an ornamental flower crop. It is native to the northern hemisphere chiefly Europe and Asia. On account of its origin and commercial production in Asia it is called as, 'Queen of East' or 'Glory of East' and sometimes 'Winter Queen' as the flowers are available during winter. Historically, Confucius the great Chinese philosopher has mentioned chrysanthemum as early as in 500 BC making it one of the most ancient cultivated flowers of the world. It has wide range of colors, shapes and sizes. The vase life of this flower varies from 10-15 days and if stored in dry form, they can remain attractive for longer periods (Baskaran *et al.*, 2009) [5]. Light, temperature and relative humidity are the most important limiting factors for plant growth and development. Adverse effect of these climatic factors may lead to low yields or complete failure of the crop. Hence, the effect of Date or season of planting on growth and development of chrysanthemum is highly important for commercial cultivation (Kulkarni and Reddy, 2010) [11]. Larger spacing helps to the terminal portion of main stem and shoot promotes production of large number of secondary branches resulting in well spread bushy plant and a greater number of good quality flowers.

Materials and Methods
The experiment was conducted at the Horticulture Garden, Department of Horticulture, College of Agriculture, Raichur, Karnataka, during the year 2018-19 and 2020-21. The region falls under Agro-Climatic Zone-II North-Eastern dry zone of Karnataka. Raichur is located at 16.21° N latitude, 77.35° E longitude and an altitude of 407 meters above mean sea level. Transplanting of suckers was done according to different months of planting time at different levels of spacing during early morning or late in the evening followed by immediate irrigation. The observations on growth parameters were recorded at different growth stages of the plants. The experiment was laid out in split plot design with fifteen treatment combinations and three replications. The treatments comprised of five different months as planting time *viz.*, second fortnight of August (M_1), second fortnight of September (M_2), second fortnight of October (M_3), second fortnight of November (M_4) and second fortnight of December (M_5), and three levels of spacing *i.e.*, spacing 45 × 30 cm (S_1), spacing 30 × 30 cm (S_2) and spacing 45 × 45 cm (S_3).

Results and Discussion

The result indicates that the different transplanting time and spacing had produced significant effect on growth parameters *viz.*, plant height (cm), number of secondary branches, stem diameter (mm), days taken for flower bud initiation (days), number of flowers, flower yield per plot (kg) and flower yield per hectare (t ha^{-1})

Plant height

The significant effect of month of planting on plant height was presented in Table 1. The maximum plant height (47.93, 47.16 and 47.54 cm at harvest) was recorded in the plants transplanted during the second fortnight of August (M_1) whereas minimum plant height (39.18, 38.74 and 38.96 cm at harvest) was noted in the plants transplanted during the second fortnight of December (M_5) during the year 2018, 2020 and also in pooled data of both the years, respectively. Similarly, the plants transplanted at the spacing of 45 cm × 45 cm (S_3) recorded the maximum plant height (44.55, 43.83 and 44.13 cm at harvest) whereas the minimum plant height (42.97, 42.25 and 42.61 cm at harvest) was noted in the plants transplanted at the spacing of 30 cm × 30 cm (S_2) during the year 2018, 2020 and also in pooled data of both the years, respectively. The interaction effect *i.e.* transplanting of the plants during second fortnight of August at the spacing of 45 cm × 45 cm (M_1S_3) was found the maximum plant height (48.73, 47.87 and 48.30 cm at harvest) which was also significantly differ with the transplanting of plants during the second fortnight of September at the spacing of 45 cm × 30 cm (M_2S_3) (48.73, 47.87 and 48.30 cm at harvest) whereas the minimum plant height (38.40, 38.03 and 38.22 cm at harvest) was found in the interaction of the plants transplanted during second fortnight of December and at the spacing of 30 cm × 30 cm (M_5S_3) during the year 2018, 2020 and also in pooled data of both the years, respectively. This might be due to the availability of congenial growing conditions for the growth of chrysanthemum plants during November-December months and subsequently the plants could able to put up more vegetative growth. These results were in close agreement to the earlier work of Karuppaiah and Krishna (2005) [10] in *Tagetes patula*. Similar results were also obtained by Dilta *et al.* (2006) [8], Yadav *et al.* (2007) [18], and Dorajeerao and Mokashi (2013) [9]. In case of spacing, the maximum plant height was observed in the plants transplanted at the spacing of 45 × 45 cm compared to the spacing 30 cm × 30 cm. This might be due to the fact that the plants at the spacing of 45 cm × 45 cm will get the enough sunlight, air and nutrients for the growth and development compared to the plants at 30 cm × 30 cm spacing. A similar response of spacing with respect to height of the plant have been reported by Beniwal *et al.* (2003) [7] in chrysanthemum cv "Flirt", Kulkarni and Reddy (2010) [11] in chrysanthemum cv. Saraval.

Number of secondary branches per plant

The maximum number of secondary branches (8.82, 8.49 and 8.66 at harvest) were recorded in the plants transplanted during the second fortnight of August (M_1) followed by second fortnight of September (M_2) (8.40, 8.13 and 8.13 at harvest), while the minimum number of secondary branches (7.31, 6.98 and 7.14 at harvest) were recorded in the last month of planting *i.e.*, second fortnight of December (M_5) during both the years and in pooled data, respectively. Chrysanthemum transplanted at the spacing of 45 cm × 45 cm (S_3) resulted in significantly maximum number of secondary branches (8.88, 8.55 and 8.71 at harvest) whereas minimum number of secondary branches (7.41, 7.31 and 7.14 at harvest) was noted in the spacing of 30 cm × 30 cm (S_1) during 2018, 2020 and in pooled data respectively. The interaction effect of month of planting and spacing *i.e.*, transplanting during second fortnight of August at the spacing of 45 cm × 45 cm (M_1S_3) resulted in maximum number of secondary branches (9.60, 9.27 and 9.43 at harvest) whereas minimum number of secondary branches (6.80, 6.47 and 6.63 at harvest) were recorded in the chrysanthemum transplanted during second fortnight of December at the spacing of 30 cm × 30 cm (M_5S_2) during both the years and in pooled data, respectively. Significant variation in number of secondary branches of the plant was observed when the plants were grown at different spacing in both the years. The linear growth of the plant increased with increase in plant population. Similar trend was reported by Sheetal and Harinder (2020) [16]. Plants grown at a distance of 45 cm × 45 cm produced the higher number of secondary branches per plants. Almost similar type of observation was reported by Mohanty *et al.* (2015) [12] in African marigold. The number of secondary branches of the plant increased with increase in plant population per unit area. Here maximum secondary branches were recorded with plant spacing of 45 cm × 45 cm.

Table 1: Effect of month of planting and spacing on growth parameters in chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. Marigold

	Plant height (cm) at harvest			No. of secondary branches at harvest			Stem girth (mm) at harvest		
	2018	**2020**	**POOLED**	**2018**	**2020**	**POOLED**	**2018**	**2020**	**POOLED**
M_1	47.93	47.16	47.54	8.82	8.49	8.66	11.33	11.22	11.28
M_2	46.87	46.16	46.51	8.40	8.13	8.27	10.45	10.42	10.43
M_3	42.54	41.73	42.41	8.02	7.78	7.90	10.09	10.04	10.06
M_4	41.73	41.12	41.43	7.71	7.40	7.56	09.94	09.83	09.89
M_5	39.18	38.74	38.96	7.31	6.98	7.14	09.79	09.71	09.75
S.Em.±	0.22	0.15	0.18	0.06	0.07	0.06	0.06	0.05	0.06
CD at 5%	0.72	0.5	0.58	0.21	0.22	0.21	0.2	0.17	0.18
SUB PLOT									
S_1	43.56	42.87	43.21	7.87	7.59	7.73	10.40	10.32	10.36
S_2	42.97	42.25	42.61	7.41	7.13	7.27	9.780	9.970	10.00
S_3	44.43	43.83	44.13	8.88	8.55	8.71	10.04	10.45	10.48
S.Em.±	0.11	0.08	0.09	0.03	0.02	0.03	0.03	0.04	0.03
CD at 5%	0.33	0.25	0.27	0.1	0.07	0.08	0.09	0.11	0.1
INTERACTION									
M_1S_1	48.17	47.30	47.73	8.73	8.33	8.53	11.39	11.18	11.29
M_1S_2	46.90	46.30	46.60	8.13	7.87	8.00	11.18	11.13	11.15

M_1S_3	48.73	47.87	48.30	9.60	9.27	9.43	11.42	11.35	11.39
M_2S_1	47.10	46.30	46.70	8.27	8.07	8.17	10.55	10.54	10.54
M_2S_2	45.73	44.87	45.30	7.73	7.33	7.53	10.14	10.13	10.14
M_2S_3	47.77	47.30	47.53	9.20	9.00	9.10	10.64	10.59	10.62
M_3S_1	42.40	41.53	41.97	7.87	7.67	7.77	10.11	10.11	10.11
M_3S_2	41.50	40.67	41.97	7.40	7.20	7.30	09.89	09.73	09.77
M_3S_3	43.73	43.00	41.08	8.80	8.47	8.63	10.34	10.27	10.30
M_4S_1	41.00	40.50	43.37	7.60	7.27	7.43	10.04	09.97	10.00
M_4S_2	42.30	41.37	40.75	7.00	6.80	6.90	09.60	09.45	09.52
M_4S_3	41.90	41.50	41.83	8.53	8.13	8.33	10.18	10.09	10.14
M_5S_1	39.13	38.70	41.70	6.87	6.60	6.73	09.89	09.80	09.84
M_5S_2	38.40	38.03	38.92	6.80	6.47	6.63	09.49	09.39	09.44
M_5S_3	40.00	39.50	39.75	8.27	7.87	8.07	10.00	09.95	09.98
S.Em.±	0.36	0.26	0.29	0.11	0.07	0.08	0.1	0.12	0.1
CD at 5%	1.06	0.78	0.85	0.33	0.22	0.24	0.3	0.34	0.3

Table 2: Effect of month of planting and spacing on flowering parameters in chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. Marigold

	Days taken for flower bud initiation (days)			**Number of flowers per plant**			**Flower yield per plot (kg)**			**Flower yield per hectare (t ha^{-1})**		
	2018	**2020**	**Pooled**	**2018**	**2020**	**Pooled**	**2018**	**2020**	**Pooled**	**2018**	**2020**	**Pooled**
M_1	46.49	45.76	46.12	42.78	41.22	42.00	6.36	6.07	6.21	5.88	5.62	5.75
M_2	44.61	43.81	44.21	41.11	39.67	40.39	5.87	5.62	5.74	5.43	5.21	5.32
M_3	43.64	42.90	43.27	38.44	36.78	37.61	5.33	5.12	5.23	4.94	4.74	4.84
M_4	41.36	40.43	40.89	32.89	31.56	32.22	3.99	3.83	3.91	3.69	3.55	3.62
M_5	37.17	36.53	36.85	28.22	27.00	27.61	3.5	3.33	3.42	3.24	3.09	3.16
S.Em.±	0.18	0.16	0.16	0.4	0.4	0.39	0.14	0.13	0.13	0.13	0.12	0.10
CD at 5%	0.58	0.52	0.51	1.31	1.3	1.27	0.45	0.42	0.44	0.42	0.39	0.34
Sub plot												
S_1	42.66	41.79	42.22	36.4	35.07	35.73	4.95	4.71	4.83	4.58	4.36	4.47
S_2	43.61	42.76	43.19	34.13	32.60	33.37	5.59	5.4	5.49	5.17	5.00	5.09
S_3	41.69	41.11	41.40	39.53	38.07	38.8	4.49	4.28	4.39	4.16	3.96	4.06
S.Em.±	0.09	0.08	0.08	0.17	0.22	0.19	0.04	0.05	0.04	0.04	0.04	0.05
CD at 5%	0.25	0.25	0.23	0.51	0.64	0.55	0.13	0.14	0.13	0.12	0.13	0.15
Interaction												
M_1S_1	46.43	45.43	45.93	42.33	41.33	41.83	6.20	5.90	6.05	5.74	5.46	5.60
M_1S_2	47.17	46.47	46.82	39.67	37.67	38.67	7.13	6.90	7.02	6.6	6.39	6.50
M_1S_3	45.87	45.37	45.62	46.33	44.67	45.50	5.73	5.40	5.57	5.31	5.00	5.15
M_2S_1	44.53	43.73	44.13	40.67	39.33	40.00	5.73	5.40	5.57	5.31	5.00	5.15
M_2S_2	45.63	44.97	45.30	38.33	36.67	37.50	6.67	6.43	6.55	6.17	5.96	6.06
M_2S_3	43.67	42.73	43.20	44.33	43.00	43.67	5.20	5.03	5.12	4.81	4.66	4.74
M_3S_1	43.63	42.63	43.13	38.33	36.33	37.33	5.20	4.97	5.08	4.81	4.6	4.71
M_3S_2	44.57	43.63	44.10	35.67	34.33	35.00	6.00	5.80	5.90	5.56	5.37	5.46
M_3S_3	42.73	42.43	42.58	41.33	39.67	40.50	4.80	4.60	4.70	4.44	4.26	4.35
M_4S_1	41.50	40.63	41.07	32.33	31.00	31.67	4.07	3.93	4.00	3.77	3.64	3.70
M_4S_2	42.57	41.40	41.98	30.67	29.33	30.00	4.30	4.17	4.23	3.98	3.86	3.92
M_4S_3	40.00	39.27	39.63	35.67	34.33	35.00	3.60	3.40	3.50	3.33	3.15	3.24
M_5S_1	37.20	36.50	36.85	28.33	27.33	27.83	3.53	3.33	3.43	3.27	3.09	3.18
M_5S_2	38.13	37.33	37.73	26.33	25.00	25.67	3.83	3.70	3.77	3.55	3.43	3.49
M_5S_3	36.17	35.77	35.97	30.00	28.67	29.33	3.13	2.97	3.05	2.9	2.75	2.82
S.Em.±	0.27	0.27	0.24	0.54	0.68	0.59	0.14	0.15	0.14	0.13	0.14	0.16
CD at 5%	0.79	0.78	0.72	1.61	2.02	1.73	0.41	0.43	0.41	0.42	0.4	0.49

Stem girth

The plants transplanted during second fortnight of August (M_1) resulted in maximum stem girth (11.33, 11.22 and 11.28 mm at harvest) followed by second fortnight of September (M_2) (10.45, 10.42 and 10.43 mm at harvest) whereas minimum stem girth (9.79, 9.71 and 9.75 mm at harvest) was noted in the plants transplanted during second fortnight of December (M_5) during both the years and in pooled data, respectively. Similarly, chrysanthemum planted at the spacing of 45 cm × 45 cm (S_3) resulted in significantly maximum stem girth (10.52, 10.45 and 10.48 mm at harvest) whereas minimum stem girth (10.04. 9.97 and 10.00 at harvest) was noted in the spacing of 30 cm × 30 cm (S_2) during both the years and in pooled data, respectively. The interaction of transplanting during second fortnight of august and spacing of 45 cm × 45 cm (M_1S_3) noted the maximum stem girth (11.42, 11.35 and 11.39 mm at harvest) followed by M_1S_2 (Planting during second fortnight of august and spacing of 30 cm × 30 cm) (11.39, 11.18 and 11.29 at harvest). However, the treatment combination M_5S_2 (Planting during first fortnight of December and spacing of 30 cm × 30 cm) had resulted in minimum stem girth (9.49, 9.39 and 9.44 mm at harvest) during both the years and in pooled data, respectively. Significant variation in stem girth of the plant was observed

when the plants were grown at different spacing in both the years. The linear growth of the increased stem girth was observed in lesser plant population. Similar trend was reported by Sheetal and Harinder (2020) [16]. Plants grown at the distance of 45 cm × 45 cm produced the higher stem girth.

Days taken for flower bud initiation

The data pertaining to days taken for flower bud initiation was presented in the Table 2. The maximum days taken for flower bud initiation(46.49, 45.76 and 46.12 days) was noted in the plants transplanted during second fortnight of August (M_1) whereas, minimum days taken for flower bud initiation (37.17, 36.53 and 36.85 days)recorded in the late transplanting *i.e.,* second fortnight of December (M_5)during both the years and in pooled data, respectively. Similarly, the highest days taken for flower bud initiation (43.61, 42.76 and 43.19 days) was noted in the spacing of 45 cm × 45 cm (S_3)whereas, lowest days taken for flower bud initiation (41.69, 41.11 and 41.40 days) was noted in the spacing of 30 cm × 30 cm (S_2) during both the years and in pooled data, respectively. Interaction effect of transplanting during second fortnight of August and spacing of 30 cm × 30 cm (M_1S_2) noted the maximum days taken for flower bud initiation (47.17, 16.47 and 46.82 days) and minimum days taken for flower bud initiation (36.17, 35.77 and 35.97 days) was noted in the second fortnight of December and spacing of 45 cm × 45 cm (M_5S_3) during both the years and in pooled data, respectively. The reason might be that long day conditions experienced by the August planting produced more photosynthates and other growth promoting substances which resulted in more vegetative growth and hence, flowering was delayed. However, September onwards, there were short day conditions that resulted in early bud formation. These results were in confirmation with the findings of Arora and Khanna (1998) [3] and Swati (2020) [17] in African marigold who observed the apical flower bud formation hasten after October and before March plantings mainly due to short day conditions.

Number of flowers per plant

The maximum number of flowers (42.78, 41.22 and 42.00) was noted in the second fortnight of August (M_1) planting and minimum number of flowers (28.22, 27.00 and 27.61) was recorded in the second fortnight of December (M_5) planting during both the years and in combined data, respectively. Similarly, the maximum number of flowers (39.53, 38.07 and 38.80) was noted in the spacing of 45 cm × 45 cm (S_3) and minimum number of flowers (34.13, 32.60 and 33.37) in the spacing of 30 cm × 45 cm (S_2) during both the years and pooled data, respectively. Among the interaction effects, the maximum number of flowers (46.33, 44.67 and 45.50) were resulted in the second fortnight of August planting and spacing of 45 cm × 45 cm (M_1S_3) whereas the minimum number of flowers (26.33, 25.00 and 25.67) were recorded in the second fortnight of December and spacing of 30 cm × 30 cm (M_5S_2) during 2018, 2020 and in pooled data, respectively. Early planted plants attained increased height and produced higher number of branches hence they produced maximum number of flower buds that ultimately resulted in more flowers. Higher number of flower production might be due to the dominating effect of early planting and higher number of leaves. Additionally, due to prolonged period of photosynthetic activity, the plants had sufficient food reserves to convert it in to more flowering buds (Basoli, 2009) [6]. These findings were also supported by the findings of Palai *et al.* (2018) [14] in chrysanthemum who observed that number of flowers decreased in delayed planting. Ahir *et al.* (2021) [1] recorded lowest number of flowers in second fortnight of December planting in China aster. Moreover, Muhammad *et al.* (2000) [13] also reported higher flower yield in august planting in Dahlia.

Flower yield per plot

The maximum flower yield per plot (6.36, 6.07 and 6.21 kg) was noted in the second fortnight of August (M_1) planting whereas the minimum flower yield per plot (3.50, 3.33 and 3.42 kg) recorded in the second fortnight of December (M_5) transplanting during both the experimental years and in the pooled data, respectively. Similarly, higher flower yield per plot (5.59, 5.40 and 5.49 kg) was reported at the spacing of 30 cm × 30 cm (S_2) and lower flower yield per plot (4.49, 4.28 and 4.39 kg) was recorded at the spacing of 45 cm × 45 cm (S_3)during both the years and in the pooled data, respectively. Among interaction effects of month of planting and spacing, maximum flower yield per plot (7.13, 6.90 and 7.02 kg) noted in second fortnight of August planting at the spacing of 30 cm × 30 cm (M_1S_2) whereas the minimum flower yield per plot (3.13, 2.97 and 3.05 kg) was noted in the second fortnight of December planting at the spacing of 45 cm × 45 cm (M_5S_3) during 2018, 2020 and in the pooled data, respectively. Early month of planting results in the increased yield which could be attributed to the better growth and yield parameters such as plant height, number of branches per plant, leaf area and stem girth which were observed to be significantly higher at all stages of observation. All these factors at their maximum extent by transplanting chrysanthemum during second fortnight of August had influenced in obtaining significantly higher flower yield per plot. The second fortnight of August planting makes the availability of optimum environmental factors for production of better flowers and establishment of the plant. The results were in accordance with the findings of Sharifuzzaman *et al.* (2011) [15] and Bajad *et al.* (2017) [4].

Flower yield per hectare

The maximum flower yield per hectare (5.88, 5.62 and 5.75 t) was noted in the chrysanthemum transplanted during the second fortnight of August (M_1) whereas, minimum flower yield per hectare (3.24, 3.09 and 3.16 t) was found in the second fortnight of December planting (M_5) during both the experimental years and in the pooled data, respectively. Similarly, maximum flower yield per hectare (5.17, 5.00 and 5.09 t) was recorded at the spacing of 30 cm × 30 cm (S_2) and the minimum flower yield per hectare (4.16, 3.96 and 4.06 t) was reported at the spacing of 45 cm × 45 cm (S_3) in both the years and in the pooled data, respectively. Whereas, the maximum flower yield per hectare (6.60, 6.39 and 6.50 t) was recorded in the chrysanthemum transplanted during the second fortnight of August at the spacing of 30 cm × 30 cm (M_1S_2) and minimum flower yield per hectare (2.90, 2.75 and 2.82 t) was noted in the chrysanthemum transplanted during the second fortnight of December at the spacing of 45 cm × 45 cm (M_5S_3) during 2018, 2020 and in pooled data, respectively. The treatment combination M_1S_2 (planting during second fortnight of august at the spacing of 30 cm × 30 cm) has recorded significantly higher yield per plot which in turn leading to the increased total flower yield per hectare.

Higher growth parameters like plant height, number of branches per plant and leaf area in the early planted chrysanthemum might have influenced on total flower yield. The rise in temperature during the growth period of late planting (M_5) of chrysanthemum increases the rate of respiration which results in more utilization of carbohydrates and other products of photosynthesis. Due to this, the lesser quantity of assimilates is available for translocation from source to sink during the flowering period. At closer spacing of 30 cm × 30 cm, yield per hectare is higher compared to wider spacing of 45 cm × 45 cm. The results were in accordance with the findings of Sharifuzzaman *et al.* (2011) [15] and Ambed and Kadam 1998 [2].

Conclusion

The observations recorded from the present investigation revealed that among the five different planting times, second fortnight of august transplanting resulted an effective and balanced plant growth and production of higher number of good quality flowers.

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