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Impact of planting geometry and nutrition studies on the performance in chrysanthemum (*Dendranthema grandiflora* Tzvelev)

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Abstract
A field experiment was carried out to study the effect of planting geometry and nutrition studies in chrysanthemum (*Dendranthema grandiflora* Tzvelev). The experiment was laid out in Factorial Randamized Complete Block Design with three factors in two replications at college of horticulture, Bengaluru. Result of the study revealed that, Among the varieties, vegetative growth and flower yield parameters were found maximum in cv. Scent Yellow (V_1), whereas, superiority in flowering attributes were observed in cv. Purple (V_2). Among different levels of spacing, closure spacing of 30 x 22.5 cm showed maximum plant height and earliness in flowering attributes, whereas, wider spacing of 45 x 45 cm resulted in better vegetative growth along with flower yield parameters. However, spacing of 45 x 30 cm exhibited maximum flower yield per hectare with higher benefit cost ratio. Among different levels of nutrition, N_3 (180:225:150 kg NPK ha^{-1}) showed better vegetative growth along with longer duration of flowering (104.38 days), higher number of flowers (101.03) and flower yield per plant (303.21 g). However, spacing of 45 x 30 cm exhibited maximum flower yield per hectare (14.71 T ha^{-1}). Among interactions, maximum plant height (65.12 cm) was noticed in $V_1S_1N_3$ combination and $V_1S_3N_3$ treatment combination exhibited maximum plant spread in East-West, North-South direction (78.49 cm and 78.23 cm, respectively), longer duration of flowering (123.80 days), higher number of flowers and flower yield per plant (163.40 and 510.79 g, respectively). Maximum flower yield per hectare (21.78 T ha^{-1}), was noticed in $V_1S_2N_3$ combination. $V_2S_1N_1$ combination showed early flower bud initiation and days to 50 per cent flowering (48.10 and 92.60 days, respectively).

Keywords: Chrysanthemum, geometry, spacing, nutrition, varieties

1. Introduction
Chrysanthemum is a leading commercial flower crop grown for production of cut flowers, loose flowers and potted plants. It is commonly known as “Queen of East” and “Autumn Queen”. It belongs to the family Asteraceae (Anderson, 1987) [3]. It grows as a compact herbaceous perennial with a well-branched structure and exhibits alternately arranged, deeply lobed leaves. The flowers are composite, comprising central disc florets surrounded by ray florets. Flower colors range from white, yellow and pink to red and purple, with considerable variation in shape and size. The plant develops a fibrous root system and can grow up to 1.5 meters tall, depending on environmental conditions and cultivar. Among different species, *Dendranthema grandiflora* Tzvelev commercially cultivated throughout the world (Patil *et al.*, 2017) [17].

Varietal diversity is crucial for farmers as it enhances crop resilience to pests, diseases and climatic variations, ensuring stable yields. Different varieties can offer improved yield potentials and better quality produce, meeting market demands and consumer preferences. This diversity also allows farmers to optimize resource use, improving overall farm productivity and sustainability. Choosing the right variety ensures optimal performance under specific environmental conditions.

Spacing and nutritional management are key factors influencing the performance of chrysanthemum crop. Plant population significantly impacts yield, with the extent of vegetative growth of individual plants being strongly affected by spacing. Excessively close spacing results

in higher competition among plants, potentially impairing crop yield. Conversely, the compensatory growth from wider spacing does not fully offset the loss of plant numbers, which can negatively affect total yield. Farmers often use varied spacing and apply fertilizers indiscriminately. Thus, it is necessary to optimize the requirements for spacing and fertilizer application to reduce production costs.

2. Materials and Methods

The experiment was conducted to study the effect of planting geometry and nutrition studies in chrysanthemum (*Dendranthema grandiflora* Tzvelev) in the Eastern Dry Zone of Karnataka (Agroclimatic Zone-V) at 12° 58" North Latitude and 77° 35" East Longitude and situated at an elevation of 930 metres above mean sea level (MSL), Department of Floriculture and Landscaping, College of Horticulture, Bengaluru, during the year 2024. The existing soil in the experimental plot was red sandy loam type with medium texture with a pH of 5.03 and having a uniform fertility condition.

The experiment field was laid out in Factorial Randomized Complete Block Design (FRCBD) with 18 treatment combinations comprising of two varieties *viz*., V_1 (*cv*. Scent Yellow) and V_1 (*cv*. Purple), three levels of spacing with paired row system of planting *viz*., S_1 (30 x 22.5 cm), S_2 (45 x 30 cm) and S_3 (45 x 45 cm) with plant population of 50, 28 and 20 plants, respectively in coresponding blocks and three levels of nutrition *viz*., N_1-100% RDF (120:150:100 kg NPK ha^{-1}), N_2-125% RDF (150:187.5:125 kg NPK ha^{-1}) and N_3-150% RDF (180:225:150 kg NPK ha^{-1}). The experiment was replicated twice. In each subplot, five plants were tagged at randomly for recording required observations and the data were recorded on quantitative and qualitative characters. From the present study, integration of planting geometry and nutrition in chrysanthemum research bring forth innovative strategies to enhance cultivation practices and can ensure higher profit by reducing cost of inputs.

3. Results and Discussion

Growth parameters

Among different growth parameters, plant height was maximum (58.72 cm) in *cv*. Scent Yellow while, minimum in *cv*. Purple. Among the different levels of spacing, 30 x 22.5 cm (S_1) has recorded highest plant height of 57.12 cm and it was lowest in 45 x 45 cm (S_3). Whereas, among different levels of nutrition, the plant height was found maximum (52.43 cm) in N_3 (180:225:150 kg NPK ha^{-1}) and it was minimum in control N_1 (120:150:100 kg NPK ha^{-1}). Among interactions, maximum plant height (65.12 cm) was recorded in the $V_1S_1N_3$ combination and minimum was observed in $V_2S_3N_1$ combination. Different varieties have distinct height characteristics, which can be amplified or moderated by the availability of nitrogen, phosphorus and potassium (Kumar *et al*., 2015) [10]. Closer spacing increases competition for light and resources, leading to taller plants, whereas wider spacing allows for more balanced growth (Ali *et al.,* 2014) [2]. Thus, the combined effects of genetic traits, nutrient availability and plant spacing creates significant height variation across chrysanthemum varieties. This variation is also reported by Divyashree *et al*. (2021) [6] in gaillardia and Naik *et al*. (2019) [14] in marigold.

Plant spread is another major vegetative growth parameter which contributes to overall plant biomass production including yield. Maximum plant spread was noticed in *cv*. Scent Yellow in East-West direction (59.79 cm) and at North-South direction (61.86 cm) and it was lowest in *cv*. Purple. Spacing of 45 x 45 cm (S_3) exhibited maximum plant spread in East-West direction (59.33 cm) and in North-South direction (63.85 cm) and it was lowest in S_1- 30 x 22.5 cm. Nutrition dose of 180:225:150 kg NPK ha^{-1} (N_3) exhibited highest plant spread in East-West direction (51.54 cm) and North-South direction (58.88 cm) and it was lowest in 120:150:100 kg NPK ha^{-1} (N_1). Among interactions, treatment combination $V_1S_3N_3$ exhibited the widest plant spread in East-West direction (78.49 cm) and North-South direction (78.23 cm) and $V_2S_1N_1$ combination showed minimum values. Varieties differ in their genetic potential for branching and spread and these factors interact with environmental conditions to influence overall plant architecture. The present results are similar with the findings of Deepa *et al*. (2008) [5] in China aster; Joshi *et al.* (2013) [9] and Harini and Fatmi (2023) [7] in chrysanthemum and Mishra (1998) [13] in gaillardia.

Flowering attributes

Among varieties, *cv*. Purple resulted in early flower bud initiation and earliness in attaining 50 per cent flowering (51.68 and 95.93 days respectively). However, it was delayed in *cv*. Scent Yellow. Plants planted in 30 x 22.5 cm registered early flower bud initiation and 50 per cent flowering (56.38 and 123.57 days, respectively) and it was delayed in 45 x 45 cm spacing. Earliness in flower bud initiation and 50 per cent flowering were reported (59.01 and 126.10 days, respectively) in N_1 (120:150:100 kg NPK ha^{-1}) treatment and maximum days to flower bud initiation and 50 per cent flowering (59.87 and 127.47 days, respectively) was registered in N_3 (180:225:150 kg NPK ha^{-1}). Earliness in flower bud initiation and 50 per cent flowering (48.10 days and 92.60 days, respectively) was observed in $V_2S_1N_1$ combination and it was delayed in $V_1S_3N_3$ combination. This might be because of increased nutrition along with wider spacing helped the plant to attain good vegetative growth and based on the varietal character earliness in flowering was decided and differed significantly. Similar results were found by Neelima *et al.* (2013) [15] and Mali *et al.* (2016) [12] in chrysanthemum and Kumar *et al.* (2020) [11] in marigold.

Duration of flowering is a very important character of any variety which signifies the availability of the flowers in the market. The *cv*. Scent Yellow exhibited maximum duration of flowering (121.02 days) and it was least in cv. Purple. Spacing of 45 x 45 cm (S_3) exhibited longer duration of flowering (104.75 days) and lesser duration of flowering was observed in 30 x 22.5 cm (S_1). N_3 (180:225:150 kg NPK ha^{-1}) treatment resulted in longer duration of flowering (104.38 days) and it was minimum in N_1 (120:150:100 kg NPK ha^{-1}). $V_1S_3N_3$ treatment combination resulted in maximum duration of flowering (123.80 days) and it was minimum in $V_2S_1N_1$ combination. Wider spacing allows plants to receive more light and air, reducing competition and leading to longer flowering periods. Additionally, balanced nutrient supply helps in extending the flowering duration. These factors work together to affect the flowering cycle of chrysanthemum across different varieties. These findings were in accordance with the results obtained by Sajid and Noorul (2014) [19]; Ahmed *et al.* (2017) [1] and Sharma *et al*. (2021) [20] in chrysanthemum.

Flower yield parameters

Among the varieties, significantly maximum number of flowers per plant and cumulative flower yield per plant (112.49 and 335.18 g, respectively) was recorded in *cv*. Scent Yellow and it was lowest in *cv*. Purple. Higher number of flowers per plant and flower yield per plant (105.12 and 319.25 g, respectively) was observed in 45 x 45 cm (S_3), whereas it was less in 30 x 22.5 cm (S_1). Among varied nutrition doses, plant with maximum number of flowers and flower yield per plant (101.03 and 303.21 g, respectively) was observed in N_3 (180:225:150 kg

NPK ha^{-1}) and it was minimum in N_1 (120:150:100 kg NPK ha^{-1}). Among interactions, higher number of flowers and flower yield per plant (163.40 and 510.79 g, respectively) in $V_1S_3N_3$ treatment combination and it was minimum in $V_2S_1N_1$ treatment combination. This might be due to production of more number of lateral branches and wider plant spread in higher level of spacing and optimum dose of nutrition which facilitates in the production of more number of flowers and flower yield depending on the diversed variation in genotypic characters of the different cultivars (Neelima *et al*., 2013) [15]. Similar conformity was obtained from the studies done by Sharma *et al.* (2021) [20] and Sachin *et al.* (2023) [18] in chrysanthemum and Hugar and Nalwadi (1998) [8] in gaillardia.

Among the chrysanthemum cultivars, *cv*. Scent Yellow produced maximum flower yield per hectare (16.11 T ha^{-1}) whereas, it was minimum in cv. Purple. Spacing of 45 x 30 cm (S_2) exhibited higher flower yield per hectare (13.23 T ha^{-1}) whereas, it was lowest in 45 x 45 cm (S_3). Among varied nutrition doses, treatment N_3 (180:225:150 kg NPK ha^{-1}) exhibited maximum flower yield per hectare (14.71 T ha^{-1}) and it was minimum in N_1 (120:150:100 kg NPK ha^{-1}). The treatment combination of $V_1S_2N_3$ yielded maximum flower yield per hectare (21.78 T ha^{-1}) and it was lowest in $V_2S_3N_1$ combination. This variation in yield among different varieties might be because of performance of varieties which are altered due to variation in environmental condition and non-suitability of the *cv*. Purple for planting in March month and its growth was retarded, still performed better for increased dose of nutrition with closer spacing by accommodating higher plant population. The results are in close conformity with the findings of Chawla *et al.* (2007) [4]; Patel and Chaudhari (2011) [16] and Darji *et al*. (2021) in chrysanthemum.

Table 1: Vegetative parameters and flowering attributes as influenced by planting geometry and nutrition in chrysanthemum

Treatment	Plant height	Plant spread (EW)	Plant spread (NS)	Days to flower bud initiation	Days to 50 per cent flowering	Total duration of flowering
Variety						
V_1 - Scent Yellow	58.72	59.79	61.86	67.28	157.62	121.02
V_2 - Purple	45.08	39.51	41.65	51.68	95.93	86.19
SE m±	0.17	0.21	0.23	0.16	0.09	0.20
CD @ 5%	0.51	0.62	0.70	0.46	0.25	0.60
Spacing						
S_1 - 30 x 22.5 cm	57.12	39.38	38.94	56.38	123.57	102.03
S_2 - 45 x 30 cm	51.91	50.24	52.49	59.52	125.95	104.03
S_3 - 45 x 45 cm	46.66	59.33	63.85	62.53	130.82	104.75
SE m±	0.21	0.26	0.29	0.19	0.10	0.30
CD @ 5%	0.63	0.76	0.86	0.57	0.31	0.90
Nutrition						
N_1 - 120:150:100 kg NPK ha^{-1}	50.84	47.50	49.32	59.01	126.10	102.77
N_2 - 150:187.5:125 kg NPK ha^{-1}	52.43	49.92	51.08	59.50	126.77	103.67
N_3 - 180:225:150 kg NPK ha^{-1}	52.43	51.54	54.88	59.87	127.47	104.38
SE m±	0.21	0.26	0.29	0.12	0.10	0.32
CD @ 5%	0.63	0.76	0.86	0.36	0.31	0.97
Interaction (V X S)						
V_1S_1	64.08	44.79	43.44	64.47	153.97	119.70
V_1S_2	58.07	61.25	65.16	66.83	156.63	120.53
V_1S_3	54.00	73.33	77.00	70.53	162.27	122.83
V_2S_1	50.16	33.98	34.45	48.30	93.17	84.37
V_2S_2	45.75	39.23	39.82	52.20	95.27	87.53
V_2S_3	39.32	45.32	50.69	54.53	99.37	86.67
SE m±	0.30	0.36	0.41	0.27	0.15	0.21
CD @ 5%	0.89	1.08	1.21	0.80	0.44	0.63
Interaction (V X N)						
V_1N_1	57.19	56.68	59.58	67.17	156.70	120.23
V_1N_2	58.86	60.39	61.68	67.30	157.57	121.27
V_1N_3	60.10	62.30	64.34	67.33	158.60	121.57
V_2N_1	44.48	38.81	39.05	51.27	95.50	85.30
V_2N_2	45.99	39.45	40.48	52.37	95.97	86.07
V_2N_3	44.76	40.77	45.42	53.40	96.33	87.20
SE m±	0.30	0.36	0.41	0.23	0.15	0.09
CD @ 5%	0.89	1.08	1.21	0.69	0.44	0.27
Interaction (S X N)						
S_1N_1	55.20	38.70	37.86	56.35	123.00	101.55
S_1N_2	57.26	40.43	38.51	56.20	123.50	101.95
S_1N_3	58.91	39.03	40.46	56.60	124.20	102.60
S_2N_1	51.27	47.09	49.60	60.75	125.40	103.45
S_2N_2	53.62	50.41	51.57	59.15	126.00	103.95
S_2N_3	50.84	53.24	56.31	58.65	126.45	104.70
S_3N_1	46.05	56.38	60.39	62.50	129.90	103.30
S_3N_2	46.40	58.92	63.17	62.45	130.80	105.10
S_3N_3	47.54	62.68	67.89	62.65	131.75	105.85
SE m±	0.37	0.44	0.50	0.33	0.18	0.20
CD @ 5%	1.09	1.32	1.48	0.98	NS	0.60

Interaction (V X S X N)						
$V_1S_1N_1$	63.06	44.26	42.23	62.60	153.40	119.40
$V_1S_1N_2$	64.06	46.50	42.92	64.20	153.80	119.80
$V_1S_1N_3$	65.12	43.61	45.16	64.60	154.70	119.90
$V_1S_2N_1$	55.28	57.45	61.12	67.40	155.50	120.00
$V_1S_2N_2$	58.51	61.50	64.72	66.70	156.60	120.60
$V_1S_2N_3$	60.42	64.81	69.63	66.40	157.80	121.00
$V_1S_3N_1$	53.24	68.34	75.38	70.00	161.20	121.30
$V_1S_3N_2$	54.01	73.17	77.39	70.60	162.30	123.40
$V_1S_3N_3$	54.75	78.49	78.23	71.00	163.30	123.80
$V_2S_1N_1$	47.33	33.78	33.49	48.10	92.60	83.70
$V_2S_1N_2$	50.46	34.36	34.10	48.20	93.20	84.10
$V_2S_1N_3$	52.70	33.79	35.75	48.60	93.70	85.30
$V_2S_2N_1$	47.26	36.72	38.07	54.10	95.30	86.90
$V_2S_2N_2$	48.72	39.31	38.41	51.60	95.40	87.30
$V_2S_2N_3$	41.26	41.67	42.98	50.90	95.10	88.40
$V_2S_3N_1$	38.85	44.42	45.60	55.00	98.60	85.30
$V_2S_3N_2$	38.99	44.67	48.94	54.30	99.30	86.80
$V_2S_3N_3$	40.32	46.87	57.54	55.30	100.20	87.90
SE m±	0.52	0.63	0.70	0.21	0.26	0.10
CD @ 5%	1.54	1.87	2.10	0.63	0.76	0.30

Table 2: Flower yield parameters as influenced by planting geometry and nutrition in chrysanthemum

Treatment	Number of flowers per plant	Flower yield per plant (g)	Flower yield per hectare (T ha^{-1})
Variety			
V_1 - Scent Yellow	112.49	335.18	16.11
V_2 - Purple	60.61	162.13	7.81
SE m±	0.38	2.08	0.10
CD @ 5%	1.13	6.22	0.29
Spacing			
S_1 - 30 x 22.5 cm	69.05	162.14	12.01
S_2 - 45 x 30 cm	85.48	264.57	13.23
S_3 - 45 x 45 cm	105.12	319.25	10.64
SE m±	0.47	2.55	0.12
CD @ 5%	1.39	7.61	0.35
Nutrition			
N_1 - 120:150:100 kg NPK ha^{-1}	73.05	188.12	9.09
N_2 - 150:187.5:125 kg NPK ha^{-1}	85.57	254.64	12.08
N_3 - 180:225:150 kg NPK ha^{-1}	101.03	303.21	14.71
SE m±	0.47	2.55	0.12
CD @ 5%	1.39	7.61	0.35
Interaction (V X S)			
V_1S_1	84.43	211.66	15.68
V_1S_2	111.63	371.03	18.55
V_1S_3	141.40	422.86	14.10
V_2S_1	53.67	112.62	8.34
V_2S_2	59.33	158.11	7.91
V_2S_3	68.83	215.64	7.19
SE m±	0.66	3.61	0.17
CD @ 5%	1.96	10.77	0.50
Interaction (V X N)			
V_1N_1	93.23	248.20	11.91
V_1N_2	109.53	344.48	16.27
V_1N_3	134.70	412.87	20.15
V_2N_1	52.87	128.03	6.27
V_2N_2	61.60	164.79	7.90
V_2N_3	67.37	193.55	9.27
SE m±	0.66	3.61	0.17
CD @ 5%	1.96	10.77	0.50
Interaction (S X N)			
S_1N_1	60.00	125.15	9.27
S_1N_2	70.20	148.99	11.04
S_1N_3	76.95	212.29	15.73
S_2N_1	72.65	200.98	10.05
S_2N_2	79.15	283.00	14.15
S_2N_3	104.65	309.75	15.49
S_3N_1	86.50	238.23	7.94

S_3N_2	107.35	331.64	11.07
S_3N_3	121.50	387.60	12.92
SE m±	0.81	4.42	0.20
CD @ 5%	2.40	13.19	0.61
Interaction (V X S X N)			
$V_1S_1N_1$	71.70	156.96	11.63
$V_1S_1N_2$	82.70	185.64	13.75
$V_1S_1N_3$	98.90	292.37	21.66
$V_1S_2N_1$	91.60	269.97	13.50
$V_1S_2N_2$	101.50	407.67	20.39
$V_1S_2N_3$	141.80	435.46	21.78
$V_1S_3N_1$	116.40	317.67	10.59
$V_1S_3N_2$	144.40	440.13	14.67
$V_1S_3N_3$	163.40	510.79	17.03
$V_2S_1N_1$	48.30	93.33	6.92
$V_2S_1N_2$	57.70	112.33	8.32
$V_2S_1N_3$	55.00	132.20	9.79
$V_2S_2N_1$	53.70	131.98	6.60
$V_2S_2N_2$	56.80	158.32	7.92
$V_2S_2N_3$	67.50	184.04	9.20
$V_2S_3N_1$	56.60	158.78	5.29
$V_2S_3N_2$	70.30	223.73	7.46
$V_2S_3N_3$	79.60	264.41	8.81
SE m±	1.14	6.25	0.29
CD @ 5%	3.40	18.65	0.86

4. Conclusion

From study, it can be concluded that the combination of closure spacing 45 x 30 cm and higher dose of nitrogen, phosphorus and potassium at 180:225:150 kg NPK ha^{-1} was beneficial to get maximum flower yield per hectare in *cv*. Scent Yellow. Whereas wider spacing of 45 x 45 cm with 180:225:150 kg NPK ha^{-1} best for getting better vegetative growth and flowering attributing characters. The *cv*. Purple recorded earliness in flowering, 50 per cent flowering and *cv*. Scent Yellow resulted in longer duration of flowering.

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