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Growth, flowering and economics of chrysanthemum cultivation as influenced by integrated nutrient management

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Abstract
An elaborate study on growth, flowering and economics of chrysanthemum cultivation as influenced by integrated nutrient management had been carried out during the two consecutive years i.e. 2016-17 and 2017-18 at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The maximum growth parameters *viz.* plant height, branches plant^{-1}, plant spread and leaf area; flowering parameters *viz.* days to emergence of first flower bud, days to flowering from flower bud emergence and days to 50% flowering and economic parameter i.e. B:C ratio were recorded with the treatment comprising of application of 75% RDF + vermicompost @ 5 t ha^{-1}+ Azotobactor + PSB.

Keywords: Azotobactor, chrysanthemum, economics, growth, management, PSB

Introduction
The crop botanically known as *Dendranthema grandiflora* Tzvelev and is belongs to family Asteraceae and is also known as 'Queen of the East'. Chrysanthemum is most interesting group among the ornamental plants in the world and represents perhaps the oldest ornamental flower. It is cultivated around big cities like Delhi, Kolkata, Lucknow, Kanpur, Bangalore and Allahabad mainly for the purpose of beautification and exhibition display. The basic concept underlying the nutrient management system (NMS), nevertheless, remains the maintenance and possible improvement of soil fertility for sustained crop productivity on long term-basis and also to reduce fertilizer input cost. Hence, an attempt was made to reduce the amount of nitrogenous, phosphatic and potassic fertilizers by substituting with organic manures and biofertilizers to increase yield and their by improve B:C ratio of chrysanthemum cultivation.

Materials and Methods
The present investigation was carried out at Floriculture Unit, Department of Horticulture, Dr. PDKV., Akola during August, 2016 to February, 2017 and August, 2017 to February, 2018. Akola is situated in sub tropical region between 220 42' N latitude and 770 02' N longitudes. The altitude of place is 307.42 m above mean sea level. The climate of Akola is semi arid and characterized by three distinct season *viz*., hot and dry summer from March to May, warm and humid rainy season from June to October and mild cold winter from November to February. Average annual precipitation is 847.30 mm.

The plantation raised on healthy, light to medium black soil. In order to understand the chemical properties of soil, a representative soil sample was collected from orchard by using appropriate soil sampling techniques. Chemical analysis was carried out in Analytical Laboratories, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The investigation was conducted in randomized block design with thirteen treatments *viz.* T_1 - 100% RDF (300:200:200 kg NPK ha-1), T_2 - 20 t Vermicompost, T_3 - 20 t Vermicompost + Azotobacter + PSB, T_4 - 60 t FYM, T_5 - 60 t FYM + Azotobacter + PSB, T_6 - 75% RDF + 5 t vermicompost, T_7 - 75% RDF + 5 t vermicompost + Azotobacter + PSB, T_8 - 50% RDF + 10 t vermicompost, T_9 - 50% RDF + 10 t vermicompost + Azotobacter + PSB, T_{10} - 75% RDF + 15 t FYM, T_{11} - 75% RDF + 15 t FYM + Azotobacter + PSB, T_{12} - 50% RDF + 30 t FYM and T_{13} - 50% RDF + 30 t FYM + Azotobacter + PSB) which were replicated thrice. The allotment of treatments to the various plots were done randomly in each replication.

Cuttings of chrysanthemum *cv.* PDKV Ragini were collected from Horticulture Section, College of Agriculture, Akola. The cuttings were prepared in July 2016 and 2017 and planted in earthen pots filled with mixture of soil, sand and FYM as media for better rooting. A regular watering, weeding and plant protection measures were carried out as and when required.

FYM and vermicompost were added at the time of land preparation whereas, biofertilizers (Azotobacter + PSB) were applied by thoroughly mixing with organic manures before transplanting as per treatments. Fertilizer dose of nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and muriate of potash, respectively. Half dose of nitrogen and full dose of phosphorus and potassium fertilizers were applied one week after planting as per the treatments. Whereas, remaining half dose of nitrogen was given one month after transplanting as per the treatments, respectively. Various intercultural operations such as Irrigation, weeding, loosening of soil, earthing up, staking, pinching and plant protection were performed as and when required.

The statistical analysis was performed as per the method suggested by Panse and Sukhatme (1995) [11].

Results and Discussion

Growth parameters

The data in respect of growth parameters was found to be significant in both the years of experimentation as influenced by nutrient management presented in table 1-3.

Maximum plant height (66.21, 70.82 and 68.52 cm, respectively), branches plant^{-1} (13.80, 14.66 and 14.23, respectively), plant spread (49.54, 54.70 and 52.12 cm, respectively) and leaf area (44.15, 42.75 and 43.45 cm^2, respectively) during both the years 2016-17 and 2017-18 as well as in pooled data was recorded with the treatment of T_7 which was significantly superior than rest of all the treatments. Whereas, significantly minimum plant height (43.51, 44.59 and 44.05 cm, respectively), branches plant^{-1} (7.00, 7.33 and 7.16, respectively), plant spread (32.11, 33.24 and 32.67 cm, respectively) was recorded under the treatment T_4. However, in case of leaf area it was recorded minimum with the treatment T_2 (28.42 cm^2) during the year 2016-17 and T_4 (26.56 and 27.65 cm^2, respectively) during the year 2017-18, as well as in pooled data respectively.

The increase in growth parameters with the treatment T_7 (75% RDF + 5 t VC + Azo + PSB) might be due to higher availability of nitrogen which favours apical dominance and maintains proper rate of cell division, which in turn leads to increased rate of meristematic activity and the beneficial effect of vermicompost, as vermicompost is a rich source of readily available macronutrients and chelated form of micronutrients such as Fe and Zn also it serves as source of organic matter and food for heterotrophic rhizosphere microflora which inturn enhances the microbial activity which might have augmented the plant growth. Another reason for increase in height is that nitrogen is fixed by *Azotobacter* and N being a constituent of protein and chlorophyll, plays a vital role in photosynthesis. It enhances accumulation of carbohydrates which in turn, increased the growth parameters. These results are in conformity with the results reported by Pandey *et al*. (2010) [10], Bohra and Kumar (2014) [2] and Patanvar *et al*. (2014) [12] in chrysanthemum, Hoda and Mona (2014) [4] in petunia, Singh *et al*. (2015) [14] in marigold and Yathindra *et al*. (2016) [16] in bird of paradise Mahadik *et al.* (2017) a[5] and Mahadik *et al.* (2017) a[7] in chrysanthemum.

Table 1: Effect of nutrient management on plant height of chrysanthemum

Treatments	Height of plant (cm)											
	30 DAT			60 DAT			90 DAT			120 DAT		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T_1 - 100% RDF	20.94	18.71	19.82	38.70	40.97	39.84	50.24	52.57	50.90	55.53	56.97	56.25
T_2 - 20 t VC	18.32	19.68	19.00	29.96	31.30	30.63	38.46	42.80	40.67	46.38	48.71	47.54
T_3 - 20 t VC + Azo + PSB	18.87	20.20	19.54	30.31	31.72	31.01	45.15	46.29	45.72	49.10	52.14	50.62
T_4 - 60 t FYM	17.84	19.25	18.54	29.68	30.20	29.94	40.42	41.60	41.01	43.51	44.59	44.05
T_5 - 60 t FYM + Azo + PSB	18.26	19.59	18.92	30.22	31.55	30.88	42.33	43.42	43.04	45.50	48.67	47.08
T_6 - 75% RDF + 5 t VC	19.37	21.61	20.49	33.30	34.62	33.96	47.94	50.94	49.44	54.60	55.90	55.25
T_7 -75% RDF + 5 t VC + Azo + PSB	22.61	24.94	21.61	37.56	39.39	38.48	58.62	60.84	59.73	66.21	70.82	68.52
T_8 -50% RDF + 10 t VC	17.30	18.71	18.00	31.11	32.56	31.84	46.77	47.24	47.00	49.82	53.72	51.77
T_9 - 50% RDF + 10 t VC + Azo + PSB	20.04	21.71	20.88	35.77	36.67	36.22	52.98	54.50	53.74	57.64	58.77	58.20
T_{10} - 75% RDF + 15 t FYM	19.24	20.91	20.08	32.86	33.46	33.16	47.27	49.80	48.54	52.38	54.79	53.59
T_{11} - 75% RDF + 15 t FYM + Azo + PSB	20.15	22.48	21.32	36.90	37.56	37.06	53.57	55.47	54.52	58.62	60.58	59.60
T_{12} - 50% RDF + 30 t FYM	19.32	21.08	20.20	30.78	31.82	31.30	45.97	46.64	46.30	49.81	53.14	51.48
T_{13} - 50% RDF + 30 t FYM + Azo + PSB	21.52	24.19	22.86	35.74	36.48	36.11	50.66	52.76	51.80	56.20	57.87	57.04
'F' Test	NS	NS	NS	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	1.100	1.363	1.234	1.681	1.679	1.499	1.853	1.982	1.544	1.928	1.767	1.807
CD at 5%	-	-	-	4.906	4.900	4.373	5.408	5.784	4.506	5.625	5.155	5.273

Table 2: Effect of nutrient management on branches plant $^{-1}$ in chrysanthemum

Treatments	Branches plant $^{-1}$											
	30 DAT			60 DAT			90 DAT			120 DAT		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T_1 - 100% RDF	2.20	2.46	2.33	5.40	5.66	5.53	10.66	9.20	9.93	12.26	12.60	12.43
T_2 - 20 t VC	1.26	1.46	1.36	3.53	3.93	3.73	7.80	8.13	7.96	8.26	8.66	8.46
T_3 - 20 t VC + Azo + PSB	1.53	1.66	1.60	3.80	4.20	4.00	7.93	8.20	8.06	9.40	9.73	9.56
T_4 - 60 t FYM	1.26	1.40	1.33	3.60	3.73	3.66	4.80	5.46	5.13	7.00	7.33	7.16
T_5 - 60 t FYM + Azo + PSB	1.76	1.60	1.68	3.73	4.06	3.90	6.66	7.00	6.83	10.86	11.20	11.03
T_6 - 75% RDF + 5 t VC	1.66	1.86	1.76	4.00	4.40	4.20	8.60	8.93	8.76	12.20	12.53	12.36
T_7 -75% RDF + 5 t VC + Azo + PSB	3.06	3.26	3.16	4.86	5.20	5.03	11.80	12.13	11.96	13.80	14.66	14.23

T_8 -50% RDF + 10 t VC	1.46	1.53	1.50	3.66	4.23	3.95	8.06	8.40	8.23	11.26	11.73	11.50
T_9 - 50% RDF + 10 t VC + Azo + PSB	1.80	2.06	1.93	4.46	4.86	4.66	10.40	10.93	10.66	12.93	13.40	13.16
T_{10} - 75% RDF + 15 t FYM	1.60	1.73	1.66	3.86	4.36	4.11	8.26	8.60	8.43	11.60	12.00	11.80
T_{11} - 75% RDF + 15 t FYM + Azo + PSB	2.06	2.33	2.20	4.66	5.00	4.83	11.20	11.53	11.36	13.46	13.80	13.63
T_{12} - 50% RDF + 30 t FYM	1.73	1.93	1.83	4.13	4.46	4.30	8.00	8.33	8.16	10.93	11.40	11.16
T_{13} - 50% RDF + 30 t FYM + Azo + PSB	2.33	2.60	2.46	4.33	4.60	4.46	8.86	10.73	9.80	12.33	12.80	12.56
'F' Test	NS	NS	NS	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.335	0.400	0.365	0.250	0.347	0.248	0.470	0.558	0.430	0.343	0.389	0.332
CD at 5%	-	-	-	0.730	1.012	0.724	1.373	1.629	1.255	1.003	1.134	0.970

Table 3: Effect of nutrient management on plant spread (cm) Leaf area (cm^2) at 50% flowering of chrysanthemum

Treatments	Plant spread (cm)			Leaf area (cm^2)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T_1 - 100% RDF	38.48	44.19	41.33	34.62	32.10	33.36
T_2 - 20 t VC	34.87	35.16	35.01	28.42	27.15	27.79
T_3 - 20 t VC + Azo + PSB	35.53	37.20	36.36	31.11	28.19	29.65
T_4 - 60 t FYM	32.11	33.24	32.67	28.73	26.56	27.65
T_5 - 60 t FYM + Azo + PSB	33.41	35.07	34.24	31.25	28.92	30.08
T_6 - 75% RDF + 5 t VC	38.26	42.07	40.17	32.86	31.06	31.96
T_7 -75% RDF + 5 t VC + Azo + PSB	49.54	54.70	52.12	44.15	42.75	43.45
T_8 -50% RDF + 10 t VC	37.48	40.60	39.04	31.71	31.04	31.37
T_9 - 50% RDF + 10 t VC + Azo + PSB	40.53	46.13	43.33	36.64	34.41	35.52
T_{10} - 75% RDF + 15 t FYM	38.04	40.63	39.33	32.79	30.55	31.67
T_{11} - 75% RDF + 15 t FYM + Azo + PSB	42.72	49.77	46.24	40.72	38.65	39.68
T_{12} - 50% RDF + 30 t FYM	36.29	38.53	37.41	31.59	31.43	31.51
T_{13} - 50% RDF + 30 t FYM + Azo + PSB	38.78	44.53	41.65	36.81	34.98	35.90
'F' Test	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	1.789	1.273	1.195	1.473	1.305	0.972
CD at 5%	5.219	3.714	3.486	4.298	3.807	2.837

Flowering parameters

The data in the respect of Flowering parameters in chrysanthemum (days) as influenced by different treatments of nutrient management studies is presented in Table 4.

The treatment T_7 had recorded significantly minimum days to emergence first flower bud (82.26, 78.60 and 80.43 days), days to flowering from flower bud emergence (29.20 26.86 and 28.03 days, respectively) and days 50% flowering (126.86, 121.33 and 124.10 days, respectively) during the year 2016-17 and 2017-18 as well as in pooled data. Whereas, significantly maximum days to emergence of first flower bud (99.13 and 97.80 days, respectively) and days to 50% flowering (153.26 and 150.00 days, respectively) was noted under the treatment T_2 during the year 2016-17 as well as in pooled data however during the year 2017-18 it was noted under the treatment T_4 (97.13 days and 148.60 days, respectively). While in the case of days to flowering from flower bud emergence it was noted maximum with the treatment T_2 (38.00 days) during the year 2016-17, and with the treatment T_4 (37.53 and 37.63 days) during the year 2017-18 as well as in pooled data.

The earliness in flowering might be attributed to amplification of nutrients especially, nitrogen, phosphorus and potassium from different sources *viz*., organic manures and inorganic fertilizers and biofertilizer, which promoted the translocation of phytohormones to the shoots resulting in the early flower initiation. It may be also due to presence of gibberellins in vermicompost which was associated with regulation of flowering as well as azotobacter and phosphobacterium might have indirect role, which makes the nutrient radially available along with presence of plant growth promoting substances which might have lead to early flowering through better uptake of nutrients. Optimum availability of all the nutrients to the plants thereby, plant completed its vegetative growth soon, resulting in early flowering i.e. opening of flower buds. Similar results have been reported by Patil *et al*. (2013) [13] in China aster, Moghadam and Shoor (2013) [8] and Palagani *et al*. (2013) [9] in Chrysanthemum. Thumar *et al*. (2013) [15] in marigold, Dalawai and Naik (2014) [3] in Carnation and Mahadik *et al*. (2017) a[5] in chrysanthemum.

Table 4: Effect of nutrient management on days to emergence of first flower bud, days to flowering from flower bud emergence and days to 50% flowering in chrysanthemum

Treatments	Days to emergence of first flower bud			Days to flowering from flower bud emergence			Days to 50% flowering		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T_1 - 100% RDF	89.73	88.50	89.11	32.53	33.26	32.90	133.46	134.13	133.80
T_2 - 20 t VC	99.13	96.46	97.80	38.00	35.73	36.86	153.26	146.73	150.00
T_3 - 20 t VC + Azo + PSB	95.66	92.66	94.16	37.13	36.20	36.66	147.86	139.26	143.56
T_4 - 60 t FYM	97.80	97.13	97.46	37.73	37.53	37.63	149.80	148.60	149.20
T_5 - 60 t FYM + Azo + PSB	96.26	94.33	95.30	37.20	35.66	36.43	145.40	144.53	144.96
T_6 - 75% RDF + 5 t VC	91.40	88.93	90.16	35.80	33.93	34.86	140.06	135.26	137.66
T_7 -75% RDF + 5 t VC + Azo + PSB	82.26	78.60	80.43	29.20	26.86	28.03	126.86	121.33	124.10
T_8 -50% RDF + 10 t VC	94.80	90.06	92.43	36.40	33.40	34.90	142.93	138.06	140.50
T_9 - 50% RDF + 10 t VC + Azo + PSB	90.93	83.40	87.16	34.06	30.86	32.46	134.20	126.80	130.50
T_{10} - 75% RDF + 15 t FYM	92.53	90.00	91.26	35.66	34.80	35.23	141.66	137.33	139.50
T_{11} - 75% RDF + 15 t FYM + Azo + PSB	84.60	81.26	82.93	30.80	28.66	29.73	127.53	122.86	125.20

T_{12} - 50% RDF + 30 t FYM	94.86	90.66	92.76	36.13	35.06	35.60	144.60	139.06	141.83
T_{13} - 50% RDF + 30 t FYM + Azo + PSB	91.16	87.73	89.45	35.40	32.73	34.06	139.53	133.86	136.70
'F' Test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) +	2.715	3.087	2.695	1.770	1.805	1.542	4.150	4.655	3.952
CD at 5%	7.923	9.008	7.864	5.166	5.268	4.500	12.109	13.583	11.532

Economic parameters

The data in respect of B:C ratio as influenced by different treatments of nutrient management is presented in Table 5.

During both years (i.e. 2016-17 and 2017-18), the benefit cost ratio showed that, treatment T_7 was most remunerative for cultivation of chrysanthemum with maximum B:C ratio (2.92, 3.50 and 3.21, respectively), followed by treatment T_{11} (2.49 2.97 and 2.73, respectively) whereas, treatment T_4 was recorded minimum B:C ratio (1.01 1.36 and 1.18, respectively). The higher net returns and B:C ratio was found with the treatment receiving 75% RDF + 5 t VC + Azo + PSB was due to higher yield of good quality flower which fetch good market prices comparatively less cost of the manures. Above result are similar to the results obtained by Airadevi and Mathad (2012) [1] and Mahadik *et al.* (2017) [6] in chrysanthemum.

Table 5: Effect of nutrient management on B:C ratio

Treatments	Cost benefit ratio		
	2016-17	2017-18	Pooled
T_1 - 100% RDF	2.31	2.69	2.50
T_2 - 20 t VC	1.15	1.38	1.26
T_3 - 20 t VC + Azo + PSB	1.39	1.65	1.52
T_4 - 60 t FYM	1.01	1.36	1.18
T_5 - 60 t FYM + Azo + PSB	1.10	1.36	1.22
T_6 - 75% RDF + 5 t VC	2.00	2.28	2.14
T_7 -75% RDF + 5 t VC + Azo + PSB	2.92	3.50	3.21
T_8 -50% RDF + 10 t VC	1.65	2.13	1.89
T_9 - 50% RDF + 10 t VC + Azo + PSB	2.41	2.88	2.65
T_{10} - 75% RDF + 15 t FYM	1.68	1.96	1.82
T_{11} - 75% RDF + 15 t FYM + Azo + PSB	2.49	2.97	2.73
T_{12} - 50% RDF + 30 t FYM	1.31	1.40	1.34
T_{13} - 50% RDF + 30 t FYM + Azo + PSB	1.66	1.96	1.81

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