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EFFECT OF DIFFERENT NPK LEVELS AND BIOFERTILIZERS ON GROWTH AND FLOWERING CHARACTERS OF CHRYSANTHEMUM (*Chrysanthemum morifolium* Ramat.)

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ABSTRACT
An experiment was carried out during 2019-2020, to investigate the effect of different NPK levels and biofertilizers on vegetative and flowering characters of chrysanthemum (*Chrysanthemum morifolium* Ramat.) variety 'White Star'. The treatments comprised of combinations of three levels of recommended dose of NPK (100% RDF, 80% RDF and 60% RDF) and four biofertilizers (*Azotobacter*, PSB, KMB and NPK consortia). Among the treatments, maximum plant height at 30, 60 & 90 days after transplanting and at full bloom stage (16.17 cm, 29.67 cm, 52.80 cm and 58.17 cm, respectively), number of primary branches (5.80), plant spread (72.72 cm), number of leaves per plant (84.23) and number of suckers (5.99) were recorded in treatment T_6 (80% RDF + NPK consortia). Flowering characters were also significantly influenced by the treatments and earliest bud initiation (76.00 days), colour break stage (94.88 days), 50% flowering (109.80 days) and full bloom stage (115.30 days) was recorded in T_6. Number of flowers per plant (10.40), flower diameter (12.68 cm), cut stem length (44.08 cm) and vase life of flowers (14.18 days) was recorded maximum in the same treatment.

INTRODUCTION

Chrysanthemum, which occupies a prominent place in ornamental horticulture, is one among the top cut flowers and pot plants traded in the world. It belongs to the family Asteraceae (Anderson, 1987) and is claimed to have originated in China (Crater, 1992). It is popularly known as 'Queen of the East' or 'Glory of the East'. Japan, China, Holland, France, England, America and India are now the major commercially chrysanthemum producing countries (Saini *et al.,* 2015). Chrysanthemum cultivation is also gaining popularity in Gujarat and both annual and perennial types are grown by farmers. Chrysanthemum is popular in Gujarat by the name 'Sevanti'. Increase in production and quality of flowers and perfection in plant forms are the important objectives to be reckoned in commercial chrysanthemum production. Though the quality and yield of cut flowers is primarily a varietal trait, it is greatly influenced by climatic, geographical and nutritional factors among which nutrition plays a major role. Chrysanthemum is a heavy nutrient feeder crop specially nitrogen and phosphorus (Nalawadi, 1982). At present, these nutrients are supplied through chemical fertilizers only. The increasing costs of fertilizers prevent their use by poor farmers (Adhikary and Gantayet, 2012). Due to rising cost, indiscriminate and continuous use of chemical fertilizers in intensive cropping system, there is imbalance of nutrients in soil which has an adverse effect on soil health, yield and quality of crop (Sunitha and Hunje, 2010). This situation emphasized the need for developing alternate production systems that are friendlier to the environment and are more judicious in managing the soil health. The inoculation of bio-fertilizers helps the plant by providing atmospheric nitrogen and rendering the insoluble phosphorus into available form (Kumar *et al.,* 2015). Increase in vegetative and flower attributes in chrysanthemum due to biofertilizers along with 50% RDF was recorded by Verma *et al.* (2011). Syamal *et al.* (2006) found that use of biofertilizers reduce per unit consumption of inorganic fertilizers and increase the quality and quantity of flowers. Increase in growth attributes in African marigold due to biofertilizers along with chemical fertilizers has been reported by Bhatt *et al.* (2016). Biofertilizers application to soil can lower nitrogenous fertilizer application and can reduce dependency on chemical fertilizers, which are responsible for soil and underground water pollution. Keeping these facts in view the present experiment was conducted to study the effect of different NPK levels and biofertilizers on growth and flowering of chrysanthemum (*Chrysanthemum morifolium* Ramat.)

MATERIALS AND METHODS

The present investigation was conducted during 2019-20 at College Farm, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, Mehsana, Gujarat. The sandy loam soil of the experimental area was fairly leveled and had uniform fertility status. One month old rooted cuttings of Chrysanthemum cv. "White Star" having uniform size and vigour were used for the experiment. *Azotobacter* and PSB were procured from Navsari Agricultural University (NAU) and KMB and NPK consortia were procured from Anand Agricultural University, Anand (AAU). For inoculating *Azotobacter*, PSB, KMB and NPK consortia, solutions were prepared by dissolving 10 ml of each in 2 liters of water separately. Rooted cuttings were dipped in the solution for 30 minutes and transplanted in the field immediately at a spacing of 30 cm x 30 cm on raised beds of 1.2 m x 1.8 m size. The cuttings were transplanted in the 2nd week of August. Nitrogen was applied in five equal split doses at 30 days interval and full doses of phosphorus and potassium (as per treatments) were incorporated in soil as basal dose. There were total eleven treatments *viz*.; T_1: 100% RDF (NPK @ 250:50:50 kg/ha); T_2: 80% RDF (NPK @ 200:40:40 kg/ha); T_3: 80% RDF + *Azotobacter*; T_4: 80% RDF + PSB; T_5: 80% RDF + KMB; T_6: 80% RDF + NPK consortia; T_7: 60% RDF (NPK @ 150:30:30 kg/ha); T_8: 60% RDF + *Azotobacter*; T_9: 60% RDF + PSB; T_{10}: 60% RDF + KMB and T_{11}: 60% RDF + NPK consortia. The experiment was laid out in Randomized Block Design (RBD) with three replications. Observations on different vegetative and flowering characters were recorded and analyzed statistically.

RESULTS AND DISCUSSION

Vegetative characters

Data pertaining to effect of different levels of NPK and biofertilizers on vegetative characters of chrysanthemum cv. "White Star" are presented in Table 1 and 2. A perusal of data clearly reveals that vegetative characters were significantly influenced by different treatments. At all the stages *i.e.*, 30, 60 & 90 days after transplanting and at full bloom stage, maximum plant height (16.17 cm, 29.67 cm, 52.80 cm and 58.17 cm, respectively) was observed in treatment T_6 *i.e.* 80% RDF + NPK consortia followed by T_3 *i.e.* 80% RDF+ *Azotobacter* (Table 1). The enhanced plant height may be due to the presence of more readily available form of nitrogen, phosphorus and potassium due to increase in the total beneficial microbial population which in turn resulted in better nutrient uptake and triggered the vegetative growth of plant. Increase in plant height at harvest due to combined application of biofertilizers with reduced dose of NPK has been also reported by Verma *et al*. (2011) in chrysanthemum and Airadevi (2012) in annual chrysanthemum.

Table 1: Effect of NPK levels and biofertilizers on plant height of chrysanthemum (cm)

Treatments	Plant height (cm)			
	30 days	60 days	90 days	At full bloom stage
T_1	14.17	24.73	45.73	51.8
T_2	12.93	24.1	44.4	50.97
T_3	15.23	27.97	48.9	55
T_4	13.87	25.7	45.47	52.53
T_5	13.67	25.57	45.13	53.03
T_6	16.17	29.67	52.8	58.17
T_7	11.63	21.7	39.87	45.4
T_8	13.37	25.27	45	50.83
T_9	12.9	24.9	44.6	49.83
T_{10}	13.03	24.24	44.2	50.23
T_{11}	13.47	25.47	42.2	53.1
S.Em. ±	0.65	1.14	1.67	1.36
C.D. at 5%	1.58	3.37	4.06	3.31

Table 2: Effect of NPK levels and biofertilizers on vegetative characters of chrysanthemum

Treatments	Number of primary branches	Plant spread (cm)	Number of leaves per plant	Number of suckers
T_1	4.27	54.67	74.4	4.72
T_2	3.97	52.85	69.68	4.55
T_3	5.23	64.39	80.17	4.94
T_4	4.9	60.91	78.43	5.48
T_5	4.53	62.89	76.13	4.79
T_6	5.8	72.72	84.23	5.99
T_7	3	50.76	61.63	3.82
T_8	3.73	54.02	67.5	4.12
T_9	3.67	53.13	64	4.77
T_{10}	3.33	52.27	63.07	4.05
T_{11}	4.37	56.54	73.4	4.95
S.Em. ±	0.28	1.45	1.84	0.21
C.D. at 5%	0.68	3.53	4.48	0.6

Data pertaining to number of primary branches showed significant difference among the treatments (Table 2). It is evident from the data that treatment T_6 (80% RDF + NPK consortia) resulted in maximum primary branches (5.80) followed by T_3 (80% RDF + *Azotobacter*). The possible reason for increase in number of branches might be conversion of unavailable macronutrients to available form and their easy uptake particularly during early crop growth phase which put forth early vigour and helps to increase number of branches. These results corroborate the findings of Verma *et al*. (2011) in chrysanthemum and Panchal *et al*. (2010) in annual chrysanthemum.

Similarly, maximum plant spread (72.72 cm) as well as number of leaves per plant (84.23) were recorded in T_6 (80% RDF + NPK consortia) followed by T_3 *i.e* 80% NPK + *Azotobacter*. Plant spread determines the size of plants in different directions and a well spread plant looks pleasing as well as produce good number of showy flowers where as leaves are the photosynthetic part of plant and yield of crop is directly correlated to the number of leaves. Plant spread and number of leaves exhibited good response to the combined application of chemical fertilizers along with biofertilizers than their individual application. The increase in number of leaves might be due to balanced availability of macro and micronutrients due to different bacteria present in NPK consortia and sufficient application of fertilizer dose. These results are in conformity with the findings of Pandey *et al*. (2018) in chrysanthemum and Kirar *et al*. (2014) in China aster. Similar results of higher plant spread due to combined application of *Azospirillum*, PSB and inorganic fertilizers have been reported in crossandra by Narshima and Haripriya (2001).

In the present study number of suckers was significantly influenced by the treatments and maximum number of suckers per plant (5.99) was observed in T_6 (80% RDF + NPK consortia). These results corroborate the findings of Palagani *et al*. (2013) in chrysanthemum.

Flowering characters

Significant influence of different treatment combinations of reduced doses of inorganic fertilizers along with biofertilizers was recorded on various floral characters *viz*., days taken to

Table 3: Effect of NPK levels and biofertilizers on flowering characters and vase life of chrysanthemum

Treatments	Days taken to bud appearance	Days taken to colour break stage	Days taken to 50% flo wering	Days taken to full bloom stage	Number of flowers per plant	Flower diameter (cm)	Cut stem length (cm)	Vase life of flowers (days)
T_1	82.93	97.73	115.2	124.8	8.17	11.02	41.07	10.39
T_2	83.13	99.13	116.63	125.77	8	10.77	39.6	10.56
T_3	78.53	96.58	112.3	119.13	9.53	12	42.67	11.89
T_4	80.1	97.33	113	120.67	9.2	11.45	41.33	13.72
T_5	80.47	97.8	114.26	121.43	8.37	10.88	40.07	12.22
T_6	76	94.88	109.8	115.3	10.4	12.68	44.08	14.18
T_7	85.73	102.33	119.2	127.17	6.94	9.94	33.66	11.04
T_8	80.6	97.47	114.9	122.83	8.04	10.8	36.07	12.1
T_9	81.57	98.93	116.27	123.23	7.97	10.57	35.77	12.33
T_{10}	82.03	99.1	117.77	124.5	7.67	10.22	35.16	12.63
T_{11}	80.37	97.17	114.6	121.73	8.32	10.9	40.3	13
S.Em. ±	0.98	0.57	0.97	0.71	0.29	0.33	0.58	0.28
C.D. at 5%	2.38	1.39	2.35	1.73	0.84	0.8	1.41	0.68

bud appearance, colour break stage, 50% flowering and full bloom stage, number of flowers per plant, flower diameter, cut stem length and vase life of flowers. The earliest bud appearance, colour break and 50% flowering was observed in T_6 (80% RDF + NPK consortia) followed by T_3 (80% RDF + *Azotobacter*. The reason for earliness in bud initiation and flowering is that NPK consortia is a kind of organic fertilizers consisting of a collection of microbes that work together so that it has more ability to degrade organic compounds and more NPK uptake. Phosphorus is an important element and essential for initiation of flowering and nitrogen, phosphorus and potassium bacteria are present in NPK consortia which might have increased the availability of phosphorus resulting in early flowering. Similar results of earliness in flowering characters were reported by Pandey *et al*. (2010) and Verma *et al*. (2011) in chrysanthemum and Kumar *et al*. (2009) in marigold.

The maximum number of flowers per plant (10.40) was observed in T_6 (80% RDF + NPK consortia). The possible reason for increase in number of flowers might be proper nitrogen, phosphorus and potassium assimilation from the 80% RDF in association with more nitrogen fixing and phosphorus solubilizing proficiency and secretion of hormones by the biofertilizers. The vigorous growth and more number of branches produced in this treatment might also have resulted in more flowers. Similar results were reported by Meshram *et al*. (2008) in annual chrysanthemum.

Similarly, maximum flower diameter (12.68 cm) and cut stem length (44.08 cm) was recorded in treatment T_6 (80% RDF + NPK consortia). Like most of the other characters, plants supplied with 60% RDF (NPK) have minimum lower diameter and stem length. The increase in flower diameter might be due to early breaking of apical dominance followed by better translocation of nutrients to the flowers by beneficial microbial inoculants *i.e.* NPK consortia. *Azotobacter* might have provided nitrogen through atmospheric fixation and PSB might have helped in increasing phosphorous availability by solubilizing fixed phosphorous in soil and making it available to plant resulting in the production of larger flowers. Similar results have been reported by Meshram *et al*. (2008) and Kumar (2015) in chrysanthemum.

Vase life of cut flowers was also influenced by the different treatments. The maximum vase life (14.18 days) was recorded with the application of 80% RDF + NPK consortia which might be due to better nutritional status of the flowers as a result of appropriate uptake of macro and micronutrients with biofertilizers inoculation thus assimilation of more photosynthates which ultimately resulted in more reserve of food and higher retention of water in the cells of flowers and lower desiccation. These results corroborate the findings of Verma *et al*. (2011).

From the above results, it can be concluded that combined use of NPK consortia and 80% RDF gives best results for vegetative and flower attributes as well as reduce the dose of chemical fertilizers upto 20% in chrysanthemum. So, there is a possibility of reducing the dose of chemical fertilizers with the use of biofertilizers, which is cost effective and eco-friendly for the sustainable cultivation of chrysanthemum.

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