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Effect of integrated nutrient management on flower yield of African marigold (*Tagetes erecta* L.) cv. Bidhan Marigold-2

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Abstract
A field experiment was carried out to study the effect of integrated nutrient management on vegetative growth and flowering of African marigold (*Tagetes erecta* L.) Cv. Bidhan Marigold-2 at Main Experimental Station, Department of Floriculture and Landscape, Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P.) during the summer season of 2018-19 and 2019-20. The experiment was laid out in Randomized Block Design with16 treatment combinations replicated thrice to assess the effect of *Azospirillum*, PSB, FYM, Vermi-compost, Poultry manure and NPK (Recommend Dose of Fertilizers).
Results reveal that the application of *Azospirillum* @ 250 ml/ha + PSB @ 250/ha ml + Vermicompost@ 50 q/ha + 50% NPK (Recommend Dose of Fertilizers) left the significant response on flower yield of African marigold Cv. Bidhan Marigold-2. The treatment has resulted in maximum number of flower per plant, flower yield plat^{-1}, flower yield plot^{-1}, flower yield ha^{-1}, and120:60:60 kg NPK (Recommend Dose of Fertilizers) left the significant response maximum number of cut flower plant^{-1}, number of cut flower ha^{-1}. Based on above results, it is concluded that the use of treatment combinations of *Azospirillum* @ 250 ml/ha + PSB @ 250/ha ml + Vermicompost@ 50 q/ha + 50% NPK (Recommend Dose of Fertilizers) and 100% NPK (Recommend Dose of Fertilizers)on African Marigold Cv. Bidhan Marigold-2 are beneficial for the growers of Eastern Uttar Pradesh.

Keywords: Marigold, *Tagetes erecta* L., flower yield, nutrient management, *Azospirillum*, PSB, vermi-compost etc.

Introduction
African marigold is an important commercial flower of India that belongs to the family Asteraceae (Composite). Marigold is a native of Central and South America especially Mexico. It also called 'Gainda' in the Hindi language. The genus *Tagetes* contain around 33 species, African marigold (*Tagetes erecta* L., 2n = 24) and French marigold (*Tagetes patula* L., 2n = 48) announced by (Rydberg, P. A., 1915) [18].
African marigold is one of the most important hardy flower crops which are grown commercially in different parts of the worlds. Marigold gained popularity among garden and flower dealers on account of its easy cultivation, wide adaptability of diverse soil and climatic conditions, the habit of profuse flowering, short duration to produce marketable flowers, and good keeping quality. In India, it is one of the most commonly grown loose flowers and extensively used on religious and social functions, in one form or another.
Agriculture, which largely depends on continuous use of chemical fertilizer is not only a burden for the farmer's or growers but is also responsible for the depletion of soil fertility which often affects productivity. Hence, efficient and judicious use of chemical fertilizers along with organic manure is imperative not only for obtaining more yields per unit area on a sustainable basis but also to conserve the energy and to avoid the problem of environmental quality.
Bio-fertilizers are the products containing living cells of different types of microorganisms, which are capable of mobilizing nutritive elements from non-usable form to usable form through a biological process. Azotobacter and PSB are free-living bacteria that help in N_2 fixation and solubilizing phosphorus in the soil. Nitrogen is an important metabolic element for the growth and development of the plant. It is essentially considered as metabolic activities, the transformation of energy, essential for the metabolism of protein and other biochemical product such as nucleic acid, chlorophyll and protoplasm.

Phosphorus is the essential component of protoplasm and chlorophyll which caused conversion of photosynthesis into phospholipids resulting in adequate vegetative growth of the plant.

Among the bio-fertilizers *Azospirillum* fix the atmospheric N_2 non-symbiotically whereas Phosphate Solubilizing Bacteria (PSB) is responsible for the increasing availability of fixed phosphorus. Phosphorus also plays an important role in energy transformation and various metabolic activities of plants. It helps in the basic reactions of photosynthesis. Potassium increases resistance in plants against drought, heat, frost and various diseases caused by fungi and nematodes. It also improves the colour, fragrance and increases the size and weight of the flowers (Tisdale *et al*., 1995, Sunitha *et al*., 2007 and Luthra *et al*., 1983) [26, 24, 10].

FYM provides the required nutrients to the plants. It provides the vital macro elements such as N (0.5-1.0%), P_2O_5 (0.4-0.8%) and K_2O (0.5-1.9%) apart from this and poultry manure provides the required nutrients to the plant. It provides the vital macro elements such as N (1.8-3.0%), P_2O_5 (1.4-1.8%) and K_2O (0.8-2.5%) apart from this and Vermicompost provide the required nutrients to the plants. It provides the vital macro elements such as N (1.49-2.0%), P_2O_5 (0.97-1.5%) and K_2O (0.45-1.2%) apart from this, it contains plant growth parameter substances such as NAA, Cytokinin, Gibberellins etc. It also harbours beneficial micro-flora within it. Organic manure also supplies secondary and microelements such as Ca, Mg, Fe, Mo, Zn, Cu etc.

Materials and Methods

The present inspection titled "Integrated Nutrient Management in Marigold (*Tagetes erecta* L.)" *cv*. Bidhan Marigold-2 was carried out at Main Experimental Station Department of Floriculture and Landscape, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya 224229 (U.P.), India during the year 2018-19 and 2019-20 in summer season. The Experiment laid out ina randomized block design with three replications and 16 different treatment combinations of bio-fertilizers and nutrients to evaluate the effect on growth and flower yield of African marigold.30 days old seedlings of African marigold, Bidhan Marigold-2variety were transplanted at 30 X 30 cm in well-prepared seedbed size 1.8 m x 1.5 min the month of April. The full dose of phosphorus through single superphosphate, potash through muriate of potash, vermin compost, poultry manure and farmyard manure were applied just before transplanting of seedlings according to the treatment combinations. The seedlings were dip with bio-fertilizers (*Azospirillum* and PSB) in the prepared solution for 30 minutes. Observations were recorded on yield characters after 120 days after transplanting and flowering attribute at a different stage of plants. The obtained data had statistically analysed adopting procedure as given by Fisher and Yates (1949).

Result and Discussion

Loose flower yield parameters

The statistical analysis of data (Table-1, 2) revealed that the yield parameters were influenced significantly due to the various combinations of bio-fertilizers and integrated nutrient management during both years of the experiment. The perusal of the data reveals that the maximum number of flower plant^{-1} (59.46 and 71.61), flower yield plant^{-1} (295.73 g and 317.46 g), flower yield plot^{-1} (8.87 kg and 9.52 kg), and flower yield ha^{-1} (328.58 q/ha and 352.72 q/ha)were observed under the application of T_{15} (*Azospirillum* @ 250 ml/ha + PSB @ 250/ha ml + Vermicompost @ 50 q/ha + 50% NPK (Recommend Dose of Fertilizers) and it was found to be significantly superior over all other treatments followed by T_{14} (*Azospirillum* + PSB + FYM + 50% NPK (Recommend Dose of Fertilizers)) treatment. The minimum number of flower plant^{-1}, flower yield plant^{-1}, flower yield plot^{-1} and flower yield ha^{-1}marigold was noticed in T_1 (100% NPK (Recommend Dose of Fertilizers)) during both the years2018-19and 2019-20as well as in pooled mean basis. Results clearly show that the combined application of *Azospirillum* @ 250 ml/ha + PSB @ 250/ha ml and Vermicompost @ 50 q/ha along with 50% NPK (Recommend Dose of Fertilizers) proved to be beneficial for the robust yield of flower as compared to other treatments. This might be due to active and rapid multiplication of bacteria especially in rhizospher creating favorable condition for nitrogen fixation and phosphorus solubilization at higher rate through nitrogen supply by nitrogenous fertilizers and supply of other nutrients, bacterial secretion, hormone production and supply of antibacterial and antifungal compounds, which were favorable for growth and ultimately increased yield. The flower yield increase in combination treatments of Azospirillum + PSB + FYM +50% nitrogen phosphorus and potassium might be due to robust growth and maximum increase in flowering span, flower diameter and flower number. Similar result was recorded by high flower yield under integrated nutrient management in marigold in number of flower per plant by Bhat *et al*., (2010) [2], Iftikhar Ahmad *et al*., (2011) [8], Shivaprakash *et al*., (2011) [20-21], Singh *et al*., (2015) [22], Patel *et al*., (2018) [14] in African marigold., flower yield per plant by Pushkar *et al*., (2008) [16], Bhat *et al*., (2010) [2], Patel *et al*., (2011) [13], Abdulsada *et al*., (2013) [1], Thumar *et al*., (2013) [25], Patel *et al*., (2018) [14], Chaupoo and Kumar, (2020) [5] in African Marigold., flower yield per plot by Natarajan and Vijayakumar, (2002) [12] in marigold, Shivaprakash *et al*., (2011) [20-21], Lakshmi *et al*., (2014) [9] in African marigold., flower yield per hectare by Chauhan *et al*., (2005) [4], Tyagi and Vijai Kumar, (2006) [27], Pushkar et al., (2008) [16], Shivaprakash *et al*., (2011) [20, 21] in African marigold.

Cut flower yield parameters

The statistical analysis of data (Table-3) revealed that the flowering parameters showed significant responses to different treatments of integrated nutrient management. With respect to days to maximum number of cut flower plant^{-1}and maximum number of cut flower ha^{-1}. The application of 100% NPK (Recommend Dose of Fertilizers) (T_1) recorded a maximum number of cut flower plant^{-1} (8.14 and 10.40), and maximum number of cut flower ha^{-1} (9.03 Lakhs and11.55 Lakhs), followed by T_2 (*Azo* +75% RDF "N" +100% RDF "P" and K (Recommend Dose of Fertilizers)) treatment were observed during both years of experiments 2018-19 and 2019-20 as well as in pooled mean basis. Results clearly show that the combined application of Azospirillum @ 250 ml/ha 90kg RDF "N" + 60kg RDF "P" and K proved to be beneficial for the robust yield of cut flowers as compared to other treatments.

Results clearly showed that the combined application of 100% recommended dose of nitrogen, phosphorus and potash proved to be reduced number of flower plant and this observation is not apply pinching of selected plant as compared to other treatments. These together led to enhance the increased number of cut flower. These results are also in close conformity with the finding of Hlatshwayo and Wahome, (2010) [7] in Carnation, Madhuri *et al*., (2014) [11] in Carnation, Singh *et al*., (2016) [23] in carnation, Harshavardhan *et al*., (2016) [6] in carnation.

Table 1: Effect of INM on number of flower per plant of African marigold.

S.N.	Treatments	No. of flower/ Plant 90 days			No. of flowers/ Plant 120 days		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	100% RDF	13.00	24.00	18.50	37.00	39.45	38.23
T_2	Azo +75% RDF "N" +100% RDF "P" and K	16.00	26.00	21.00	38.18	40.22	39.21
T_3	PSB + 75% RDF "P" + 100% RDF "N" and K	16.66	30.00	23.33	38.83	42.25	40.54
T_4	FYM + 50% RDF	18.66	32.33	25.50	39.27	44.47	41.87
T_5	VC + 50% RDF	19.33	37.33	28.33	39.48	47.40	43.44
T_6	PM + 50% RDF	21.00	37.17	29.09	38.78	44.19	41.49
T_7	Azo + FYM + 50% RDF	21.00	43.66	32.33	41.44	48.56	45.00
T_8	Azo + PM + 50% RDF	22.00	47.33	34.67	41.93	50.69	46.31
T_9	Azo+ VC + 50% RDF	23.00	50.33	36.67	45.60	53.65	49.63
T_{10}	PSB + FYM + 50% RDF	24.33	53.00	38.67	48.20	58.06	53.13
T_{11}	PSB + VC + 50% RDF	25.33	56.66	41.00	51.13	60.61	55.87
T_{12}	PSB + PM + 50% RDF	27.00	61.66	44.33	51.33	64.19	57.76
T_{13}	Azo + PSB + 50% RDF 'N' and 'P' + 100% RDF 'K'	27.66	63.66	45.67	52.96	67.32	60.15
T_{14}	Azo+ PSB + FYM + 50% RDF	30.00	66.00	48.00	54.66	69.68	62.18
T_{15}	Azo + PSB + VC + 50% RDF	32.00	68.33	50.17	59.46	71.61	65.54
T_{16}	Azo + PSB + PM + 50% RDF	29.00	63.66	46.33	53.40	68.57	60.99
	SE (m) ±	0.65	1.06	0.86	1.16	0.57	0.87
	CD at 5%	1.89	3.08	2.49	3.36	1.67	2.52

Table 2: Effect of INM on loose flower yield of African marigold

S. N.	Treatments	Flower yield / plant (g)			Flower yield / plot (kg)			Flower yield / ha(q)		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	100% RDF	107.33	122.31	114.82	3.22	3.66	3.44	119.25	135.89	127.58
T_2	Azo +75% RDF "N" +100% RDF "P" and K	118.29	130.19	124.25	3.54	3.90	3.73	131.43	144.65	138.05
T_3	PSB + 75% RDF "P" + 100% RDF "N" and K	122.81	137.94	130.38	3.68	4.13	3.91	136.45	153.26	144.86
T_4	FYM + 50% RDF	132.26	149.70	140.99	3.96	4.49	4.23	146.95	166.33	156.64
T_5	VC + 50% RDF	135.51	162.74	149.13	4.06	4.88	4.47	150.56	180.81	165.69
T_6	PM + 50% RDF	135.75	150.16	142.96	4.07	4.50	4.29	150.82	166.83	158.83
T_7	Azo + FYM + 50% RDF	145.07	169.99	157.53	4.35	5.10	4.73	161.18	188.87	175.03
T_8	Azo + PM + 50% RDF	155.15	179.08	167.12	4.65	5.37	5.01	172.38	198.97	185.68
T_9	Azo+ VC + 50% RDF	162.02	191.50	176.76	4.86	5.74	5.30	180.01	212.78	196.40
T_{10}	PSB + FYM + 50% RDF	179.75	211.08	195.42	5.39	6.33	5.86	199.72	234.53	217.13
T_{11}	PSB + VC + 50% RDF	188.41	228.27	208.34	5.65	6.84	6.25	209.33	253.63	231.49
T_{12}	PSB + PM + 50% RDF	207.21	258.10	232.66	6.21	7.74	6.98	230.23	286.77	258.50
T_{13}	Azo + PSB + 50% RDF 'N' and 'P' + 100% RDF 'K'	229.05	290.83	259.94	6.87	8.72	7.80	254.60	323.13	288.87
T_{14}	Azo+ PSB + FYM + 50% RDF	266.34	306.89	286.62	7.99	9.20	8.60	295.93	340.98	318.46
T_{15}	Azo + PSB + VC + 50% RDF	295.73	317.46	306.60	8.87	9.52	9.20	328.58	352.72	340.66
T_{16}	Azo + PSB + PM + 50% RDF	252.25	296.31	274.28	7.56	8.88	8.23	280.27	329.23	304.75
	SE (m) ±	13.61	9.71	11.67	0.40	0.29	0.35	15.12	10.79	12.96
	CD at 5%	39.52	28.18	33.86	1.18	0.84	1.02	43.90	31.31	37.61

Table 3: Effect of INM on cut flower yield of African marigold

S.N.	Treatments	Number of cut flowers/Plant			Number of cut flowers/ha (Lakhs)		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	100% RDF	17.00	18.00	17.50	8.89	11.11	10.00
T_2	Azo +75% RDF "N" +100% RDF "P" and K	16.33	18.00	17.17	8.15	10.55	9.35
T_3	PSB + 75% RDF "P" + 100% RDF "N" and K	14.00	15.33	14.67	7.78	10.44	9.11
T_4	FYM + 50% RDF	12.33	13.33	12.83	7.66	10.22	8.94
T_5	VC + 50% RDF	12.00	13.00	12.50	7.22	9.43	8.33
T_6	PM + 50% RDF	11.00	12.00	11.50	7.11	9.16	8.14
T_7	Azo + FYM + 50% RDF	8.00	9.00	8.50	7.00	8.88	7.94
T_8	Azo + PM + 50% RDF	7.33	8.00	7.67	6.77	8.33	7.55
T_9	Azo+ VC + 50% RDF	6.00	7.00	6.50	6.66	7.77	7.22
T_{10}	PSB + FYM + 50% RDF	5.00	7.66	6.33	6.55	7.78	7.17
T_{11}	PSB + VC + 50% RDF	6.00	6.00	6.00	6.45	7.22	6.84
T_{12}	PSB + PM + 50% RDF	4.00	5.00	4.50	6.22	6.83	6.53
T_{13}	Azo + PSB + 50% RDF 'N' and 'P' + 100% RDF 'K'	3.00	4.00	3.50	6.10	6.66	6.38
T_{14}	Azo+ PSB + FYM + 50% RDF	2.00	2.33	2.17	5.55	6.10	5.83
T_{15}	Azo + PSB + VC + 50% RDF	1.33	1.00	1.17	4.44	5.55	5.00
T_{16}	Azo + PSB + PM + 50% RDF	2.00	1.00	1.50	5.00	5.82	5.41
	SE (m) ±	0.64	0.70	0.67	0.43	0.33	0.38
	CD at 5%	1.86	2.04	1.95	1.26	0.98	1.12

Conclusion

Based on the finding of the experiment it is concluded that the integrated nutrient management is found to be the promising African marigold (*Tagetes erecta* L.) with respect to yield parameter *viz*., number of loose flower plant-1 (65.54), loose flower yield plant^{-1} (306.60 g), loose flower yield plot^{-1} (9.20 kg), loose flower yield ha^{-1} (340.66 q/ha) and number of cut flower plant^{-1} (17.50), number of cut flower ha^{-1} (10.00 lakhs/ha) was also recorded. This variety is suitable for commercial cultivation in eastern Uttar Pradesh for higher yield and better quality flowers.

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