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Effect of Bio-Organic and Inorganic Nutrient Sources on Growth and Flower Production of African Marigold

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Abstract: African marigold (*Tagetes erecta* L.) is one of the most important flower crops grown commercially throughout India as a loose flower for worshipping, garland making, and garden display. The productivity and quality of flowers is greatly influenced by the quantity and source of nutrients. At present, these nutrients are primarily supplied through chemical fertilizers. The indiscriminate use and complete reliance on the use of chemical fertilizers has also led to deterioration of soil health, thereby affecting sustainable flower production. Keeping these points in view, a field experiment was conducted on African marigold cv. "Orange Culcuttia" at the Horticultural Research Farm, Indira Gandhi Agricultural University, Raipur, Chhattisgarh, India. The experiment was laid out in a randomized block design with three replications and twelve treatment combinations comprised of bio-organics (Cow Urine and Vermicompost), bio-fertilizers (*Azospirillum* and Phosphate-Solubilizing Bacteria) and NPK fertilizers. Application of *Azospirillum* + Phosphate-Solubilizing Bacteria + 5% Cow Urine + 50% recommended dose of "N" through Vermicompost + 50% recommended dose of NPK fertilizer was most effective in increasing vegetative growth parameters, such as plant height, number of branches, plant spread, as well as flower yield parameters like number of flowers, flower diameter, fresh and dry weight of flowers, flower yield, flowering duration, shelf life, and it also had the maximum benefit:cost ratio. Thus, use of inorganic fertilizers conjointly with bio-fertilizers and organic manures resulted in excellent vegetative growth and flower yield attributes in African marigold.

Keywords: *Azospirillum*; bio-fertilizer; cow urine; vermicompost

1. Introduction

Among flower crops, African marigold (*Tagetes erecta* L.) is one of the most important commercially-exploited flowers throughout the world. It is in demand for loose flower production, for garland making, garden display and decorative purposes. Nutrient management plays an important role in determining flowering in African marigold. Among the various reasons behind low productivity, poor soil and nutrient management is a major cause. Therefore, nutrient management has prime importance for successful cultivation. The use of organic manures and biofertilizers along with balanced use of chemical fertilizers is known to improve the physico-chemical and biological properties of soil, besides improving the efficiency of applied fertilizers [1]. Biofertilizers improve crop growth and quality by fixation of atmospheric nitrogen and also by dissolving insoluble forms of phosphorus. *Azospirillum* (Azo) fixes atmospheric nitrogen to some extent and makes available the fixed soil nitrogen to the crop, whereas phosphorus-solubilising bacteria (PSB) possesses the ability to convert

insoluble phosphorus into soluble forms in the soil by secreting organic acids. Arancan and Edwards [2] demonstrated the effects of vermicomposts as an important organic manure for petunias, marigolds, asters, and chrysanthemums. Recently, the use of cow urine (CU) has been given importance as it may act as a growth promoter of plants and is a vital component in improving soil fertility. It not only possesses an inherent property of acting as a fertilizer but also is a mild biocide [3]. Thus, the present experiment was carried out to determine the effect of bio-organic and inorganic nutrient sources on the flower yield of marigold in view of maintaining soil health and the environment.

2. Experimental Section

The present investigation was conducted at the Department of Horticulture, Indira Gandhi Agricultural University, Raipur, Chhattisgarh, India, during the winter season of 2013–2014. The experiment was laid out in a randomized block design with three replications and twelve treatments. Individual plot size was 1.2 m × 1.2 m with a spacing of 30 cm × 30 cm. The recommended management practices of raising a healthy crop were followed. The treatments included an inorganic form of N in the form of urea (200 kg·ha^{-1}), P_2O_5 as superphosphate (200 kg·ha^{-1}) and K_2O as muriate of potash (200 kg·ha^{-1}) as 100% of the recommended dose of fertilizer (RDF). The rates of N and P were reduced in some treatments to 50% or 75% of the RDF. The NPK was applied in two parts, half the N and the full amount of P and K at the time of transplanting, and the remaining half of N was applied 40 days after transplanting. Vermicompost (VC) was applied in quantities equivalent to 50% of the recommended dose of N before planting. A slurry of 200 g of a culture of Azo and PSB were prepared in 1000 mL of water individually, and also combinations of both 100 g Azo and 100 g PSB were prepared in 1000 mL of water. Azo (200 g·ha^{-1}) and PSB (200 g·ha^{-1}) were applied by seedling root treatment for 30 min before transplanting. CU (5%) spray was applied at 30 days after transplanting. The treatment combinations were: 100% RDF (RDF), 50% RD"N" through VC + 50% RDF (VC), *Azo* + 75% RD"N" + 100% RD"P" and "K"(AZO), PSB + 75% RD"P" + 100% RD"N" and "K" (PSB), Cow Urine (5%) + 75% RD"N" + 100% RD"P" and "K" (CU), *Azo* + 50% RD"N" through VC + 50% RDF (AZVC), PSB + 50% RD"N" through VC + 50% RDF (PSVC), Cow Urine (5%) + 50% RD"N" through VC + 50% RDF (CUVC), *Azo* + PSB + 50% RD"N" and "P" + 100% RD"K" (AZPS), *Azo* + PSB + Cow Urine (5%) + 50% RD"N" and "P" + 100% RD"K" (APC), *Azo* + PSB + 50% RD"N" through VC + 50% RDF (APV), *Azo* + PSB + Cow Urine (5%) + 50% RD"N" through VC + 50% RDF (APCV). Data were recorded from five randomly-selected plants from each treatment, and included flowering behaviour, yield attributes and flower yield. Data were subjected to statistical analysis using SPSS 10.0 statistical software (SPSS Inc., Chicago, IL, USA).

3. Results and Discussion

3.1. Vegetative Growth Parameters

The different nutrient sources affected various vegetative parameters of African marigold (Table 1). The treatment APCV had the maximum plant height (53.31 cm), plant spread (37.78 cm), number of primary branches/plant (19.47) and number of secondary branches/plant (39.53) APV which, however, had at similar values. Combined application of bio-organic nutrient sources along with 50% inorganic nutrient sources proved to be beneficial for robust growth of plants as compared to other treatments. Bioinoculants like Azo and PSB may have been beneficial by fixing atmospheric nitrogen and solubilizing fixed phosphorous in the soil, making it available to plants, and also by secretion of growth substances like auxin which might have stimulated plant metabolic activity and photosynthetic efficacy leading to better growth and development. These results are in conformity with the findings of Mittal et al. [4] and Mohanty et al. [5] in marigold.

Table 1. Effect of bio-organic and inorganic nutrient sources on growth parameters of African marigold after 90 DAT.

Treatments	Plant Height (cm)	Plant Spread (cm)	No. of Primary Branches Plant^{-1}	No. of Secondary Branches Plant^{-1}
RDF	49.22	33.96	17.60	36.07
VC	4.49	29.00	15.47	28.73
AZO	46.27	30.05	16.50	31.43
PSB	46.94	31.58	16.80	31.50
CU	45.03	29.24	15.80	30.83
AZVC	47.37	32.63	17.33	32.30
PSVC	50.16	35.25	18.13	37.97
CUVC	48.59	33.74	17.40	35.40
AZPS	40.02	27.20	13.33	28.43
APC	44.23	28.94	15.53	29.27
APV	52.29	35.80	19.13	38.33
APCV	53.31	37.78	19.47	39.53
CD (p = 0.05)	**6.31**	**4.83**	**2.60**	**5.09**

3.2. Flowering and Yield Attributes

Data presented in Table 2, on flowering and yield attributes, show significant responses to different treatments of bio-organic and inorganic nutrients sources. With respect to days required for 50% flowering, the application of APCV and APV recorded the minimum number of days for 50% flowering (41.85 and 46.13, respectively). The present findings are similar to the finding of Gupta et al. [6] with marigold. The maximum flower diameter (6.18 cm) was with the application of APCV followed by APV. The same trend was observed for the highest number of flowers/plant (32.80), fresh flower weight/plant (198.83 g), and dry flower weight/plant (44.96 g), with the maximum byAPCV which also had the highest flower yield/plot (3.18 kg) and flower yield/ha (22.09 t), with APV similar.

The higher values recorded for flowering attributes and yield may be due to active and rapid multiplication of bacteria, especially in the rhizosphere, creating favourable conditions for nitrogen fixation and phosphorus solubilisation at higher rates making it available to the plants leading to more uptakes of nutrients and water. This in turn increases photosynthesis and enhances food accumulation and also diversion of photosynthates towards sinks resulting in better growth and subsequently higher number of flowers/plant and flower yield/ha [1]. The present findings are support those of Mohanty et al. [5] and Owayez Idan et al. [7] in marigold. The maximum duration of flowering (76.16 days) and longer shelf life of flowers (7.89 days) was recorded with APCV and APV. The results are in agreement with Patanwar and Sharma [8] in chrysanthemum and [6] Gupta et al. in marigold. However, the maximum B:C ratio (3.56) was found with APCV. Hence, the treatment of APCV proved to be most profitable. The optimum fertilizer use was by reducing the RDF to 50% and supplementing the deficit by using 50% vermicompost equivalent to the RDN along with Azo, PSB, and 5% cow urine , resulted in higher profit without depleting the soil macronutrients, results that agree with those of Thumar et al. [9] with African marigold.

Table 2. Effect of bio-organic and inorganic nutrient sources on yield and yield attributes of marigold.

Treatments	Days to 50% Flowering	Flower Diameter (cm)	No. of Flowers/Plant	Fresh Flower Weight/Plant (g)	Dry Flower Weight/Plant (g)	Flower Yield ($kg \cdot plot^{-1}$)	Flower Yield ($t \cdot ha^{-1}$)	Duration of Flowering (Days)	Shelf Life (Days)	Benefit Cost Ratio
RDF	48.39	5.51	30.33	175.07	37.94	2.80	19.45	72.80	7.08	3.23
VC	52.94	4.73	25.87	131.47	29.01	2.10	14.61	67.88	4.84	2.12
AZOAZO	50.91	5.15	26.60	141.74	31.64	2.27	15.75	70.15	6.25	2.40
PSBPSB	50.89	5.15	27.47	150.38	31.90	2.41	16.71	71.81	6.28	2.68
CUCU	51.08	5.01	26.53	140.17	31.58	2.24	15.57	69.08	6.24	2.35
AZVCVC	49.46	5.31	28.20	155.99	34.76	2.50	17.33	72.46	6.66	2.65
PSVCVC	46.35	6.05	31.07	180.81	39.34	2.89	20.09	73.05	7.79	3.23
CUVCVC	48.78	5.40	28.67	160.93	37.27	2.57	17.88	72.71	6.83	2.75
AZPS	53.29	4.27	22.87	106.68	28.03	1.71	11.85	62.13	4.73	1.75
APCAPC	52.48	4.89	26.33	136.79	29.94	2.19	15.20	68.25	5.23	2.45
APVVC	46.13	6.07	32.20	189.40	39.78	3.03	21.04	74.48	7.51	3.40
APCVVC	41.85	6.18	32.80	198.83	44.96	3.18	22.09	76.16	7.89	3.56
CD (p = 0.05)	6.39	0.90	5.15	32.09	7.09	0.51	3.57	7.24	1.55	-

4. Conclusions

African marigold growth and yield was higher when inorganic fertilizers were supplemented with biofertilizers and organic manures like vermicompost and cow urine as compared to only inorganic fertilizers. Application of Azo + PSB + Cow Urine (5%) + VC was found to be the most effective in increasing vegetative growth, yield attributes, and yield, and also gave the highest B:C ratio.

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