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Effect of integrated nutrient management practices on the growth, flower yield and economics of African marigold cv. Pusa Narangi Gainda

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Abstract
A field experiment was conducted to study the effect of integrated nutrient management practices on the growth and yield performance of African marigold cv. Pusa Narangi Gainda during *Rabi* 2021-22. The experiment was laid out in a randomized block design with twelve treatments replicated trice *viz*, 100% RDF (Inorganic), 100% RDF through FYM + Ghanjeevamrit + Azotobacter + PSB, 75% RDF + 25% FYM, 75% RDF + Ghanjeevamrit, 75% RDF + Azotobacter + PSB, 75% RDF + 25% FYM + Ghanjeevamrit, 75% RDF + 25% FYM + Ghanjeevamrit + Azotobacter + PSB, 50% RDF + 50% FYM, 50% RDF +Ghanjeevamrit, 50% RDF + Azotobacter + PSB, 50% RDF + 50% FYM + Ghanjeevamrit, 50% RDF + 50% FYM + Ghanjeevamrit + Azotobacter + PSB. Maximum growth parameters *viz*., plant height (99.60 cm), plant spread (63.80 cm E-W and 61.33 cm N-S), number of leaves plant^{-1} (39.84), leaf area plant^{-1} (75.67 cm^2), number of branches (22.60 and 26.47, primary andsecondary, respectively), floral characters *viz*., number of flowers plant^{-1} (53.20), flower diameter (55.92 mm), period of flowering (61.98 days), fresh weight of flower (320.26 g plant^{-1}), flower yield (8.01 kg plot^{-1} and 200.17 q ha^{-1}) and minimum days for first flower bud appearance (48.79), days for 50% flowering (57.97 days), were recorded with application of 75% RDF + 25% FYM + Ghanjeevamrit + Azotobacter + PSB, which was on par with the application of 75% RDF + 25% FYM Ghanjeevamrit, 100% RDF (Inorganic), 100% RDF through FYM + Ghanjeevamrit + Azotobacter + PSB, 50% RDF + 50% FYM + Ghanjeevamrit + Azotobacter + PSB and 50% RDF + 50% FYM + Ghanjeevamrit but significantly superior over rest of the treatments.

Keywords: Azotobacter, farm yard manure, Ghanjeevamrit, integrated nutrient management, PSB

Introduction
Marigold (*Tagetes erecta* L.) is a popular commercial annual flower of Asteraceae family, native from Central and South America, particularly in Mexico (IItus, 1945). African marigold is one of the most important hardy flower crops which are grown commercially in different parts of the worlds, gained popularity amongst gardeners and flower dealers on account of its easy culture, wide adaptability and vast range of appealing colours, shapes, and sizes, as well as its long-lasting quality (Chandrikapure *et al*., 1999) [2]. It is the most popular loose flower ranks first in India, followed by chrysanthemum, jasmine, tuberose, crossandra, and barleria and extensively used on religious and social functions, in one form or another. It is one such flower crop that could be used to extract natural colour. Marigold is known as the "versatile crop with golden harvest" because of its many uses. Marigold flowers are commonly used to make garlands, wreaths, and religious offerings, as well as for adornment. Marigold is increasing industrial importance as a result of its enormous value-adding potential. Marigold is used to make a variety of value-added goods such as pigments, meals, and culinary colorants, as well as essential oils The total area under marigold cultivation was 68.33 thousand hectares with the production of 607.97 thousand MT (NHB 2017) in India and estimated production was 755.10 thousand MT according to NHB 2021-22 (1st advanced estimate). During 2020-21 cropping season in Chhattisgarh, the area and production under marigold cultivation was 5097 ha and 53.87 MT respectively (C.G. Anonymous, 2021).The success of marigold production is determined by a number of management elements, one of which is nutrition. Nutrition plays a vital role in marigold development, flowering, and seed generation.

Therefore, nutrient management has prime importance for successful cultivation. But, the indiscriminate application of chemical fertilizers alters the soil fertility, leading to the pollution of soil and water bodies. On the other hand total organic farming may be a desirable proposition for improving the quality of agricultural produce however, it is impossible to meet the nutrient requirement of the crops, exclusively through the organic farming (Upadhyay *et al.* 2022) [12]. Under these circumstances, practice of INM is the better option for the improvement of physical (structure and water retention capacity), chemical (nutrients and cation exchange capacity) and biological (microflora and microfauna) properties. Biofertilizers and organic manures are critical components of integrated nutrition management, as they have been shown to extend vase life and improve flower quality while reducing input costs (Kumar *et al*., 2006) [6]. Therefore, a study was made to determine a suitable INM practice for marigold.

Material and Methods

The field experiment was carried out during *Rabi* season of 2021-22 at the Horticultural Research-cum-instructional Farm, College of Agriculture, IGKV, Raipur (C.G.) situated at 21°23' N latitude and 81°71' E longitude at an altitude of 291 m MSL which represents the seventh Agro Climatic Zone of India *i.e.* Eastern plateau and hills. The soil of the experimental site was Clayey m in texture, neutral in reaction (pH 7.3), high in organic carbon (0.862) and available phosphorus (22.17 kg ha^{-1}), low in available nitrogen (188 kg ha^{-1}), and medium in available potassium (239.79 kg ha^{-1}). The experiment was carried out in randomized block design (RBD) with 3 replications. The treatments contained of twelve integrated nutrient management practices.

Treatment

T_1: 100% RDF (Inorganic)
T_2: 100% RDF through FYM + Ghanjeevamrit + Azotobacter + PSB
T_3: 75% RDF + 25% FYM
T_4: 75% RDF + Ghanjeevamrit
T_5: 75% RDF + Azotobacter + PSB
T_6: 75% RDF + 25% FYM + Ghanjeevamrit
T_7: 75% RDF + 25% FYM + Ghanjeevamrit + Azotobacter + PSB
T_8: 50% RDF + 50% FYM
T_9: 50% RDF + Ghanjeevamrit
T_{10}: 50% RDF + Azotobacter + PSB
T_{11}: 50% RDF + 50% FYM + Ghanjeevamrit
T_{12}: 50% RDF + 50% FYM + Ghanjeevamrit + Azotobacter + PSB

Where, RDF was 120:80:60 N, P2O5, and K2O kg ha-1. Nursery was sown on 23-10-2021 by using 'Pusa Narangi Gainda' marigold variety and transplanted 24 days old seedlings. Manure and fertilizers were used as per the treatments. RDF was applied through urea, di-ammonium phosphate and muriate of potash. One third nitrogen, full dose of P2O5 and K2O were applied as basal at the time of transplanting. Remaining nitrogen was top dressed in two equal splits at 30 and 50 DAT equally in all treatments. FYM and Ghanjeevamrit were executed by blending while Azotobacter and PSB were applied through seedling dip method. Crop was transplanted at spacing of 40 x 40. Weeds were removed as and when they appeared and also other inter-culture operations were taken up as per package of practices. Five plants were selected randomly in each net plot to record growth parameters such as plant height, plant spread, number of leaves $plant^{-1}$, leaf area, number of primary and secondary branches $plant^{-1}$ at 30, 60 and 90 DAT. Floral characters *viz*., days taken to first flower bud appearance and 50% flowering were observed in days while number of flowers $plant^{-1}$, diameter of flower, period of flowering, fresh weight of flower $plant^{-1}$, flower yield $plot^{-1}$ and flower yield ha^{-1} were recorded at harvesting. Five peaking of marigold flowers were done. All data obtained from the investigation was statistically analyzed using *F*- test, the procedure given by Gomez & Gomez (1984) [4], critical difference (CD) values at $P = 0.05$ were used to determine the significance of differences between treatment means.

Result and Discussion

Among different level of fertilizers the tallest plants were observed with the application of 75% RDF + 25% FYM + Ghanjeevamrit + Azotobacter + PSB (T7) (99.60 cm) which was on par with 75% RDF + 25% FYM + Ghanjeevamrit (97.27 cm), 100% RDF(Inorganic) (96.13 cm), 100% RDF through FYM + Ghanjeevamrit + Azotobacter + PSB (94.33 cm), 50% RDF + 50% FYM + Ghanjeevamrit + Azotobacter + PSB (93.93 cm) and 50% RDF + 50% FYM + Ghanjeevamrit (92.67 cm) but found significantly superior over rest of the nutrient management practices. Combination of organic manure and bio-fertilizers proved to be the best for attaining the maximum plant height might be due to the upsurge in transport of metabolites and rate of photosynthesis in the plant, which empowers the plant for quick and better upward vegetative growth. Patel *et al.* (2017) [9] and Chaupoo and Kumar (2020) [3] also reported the similar results.

75% RDF + 25% FYM + Ghanjeevamrit + Azotobacter + PSB (T7) exhibited the highest plant spread (63.80 and 61.33 cm, E-W and N-S, respectively) which was on par with 75 % RDF + 25% FYM + Ghanjeevamrit, 100% RDF (Inorganic), 100% RDF through FYM + Ghanjeevamrit + Azotobacter + PSB, 50% RDF + 50% FYM + Ghanjeevamrit + Azotobacter + PSB and 50% RDF + 50% FYM + Ghanjeevamrit but significantly superior over rest of the nutrient management treatments. Treatment 50% RDF + Ghanjeevamrit (T9) proved inferior which had significantly lower plant spread as compared to other treatments. Better performance of marigold regarding plant spread (E-W and N-S) was observed when the plants were treated with biofertilizers and organic manures in combination with inorganic fertilizers as these enhance soil fertility and moisture retention capacity of soil favorable to plant growth which might have contributed to the increase in plant spread. These results were in the agreement with the findings of Patel *et al.* (2017) [9] and Chaupoo and Kumar (2020) [3].

Similarly, 75% RDF + 25% FYM + Ghanjeevamrit + Azotobacter + PSB (T7) exhibited maximum number of leaves $plant^{-1}$ and leaf area (39.84 and 75.67 cm2, respectively), 75% RDF + 25% FYM + Ghanjeevamrit, 100% RDF (Inorganic), 100% RDF through FYM + Ghanjeevamrit + Azotobacter + PSB, 50% RDF + 50% FYM + Ghanjeevamrit + Azotobacter + PSB and 50% RDF + 50% FYM + Ghanjeevamrit were similar but higher than rest of the treatments. Minimum number of leaves and leaf area were recorded under 50% RDF + Ghanjeevamrit (T9) (33.14 and

64.32 cm^2, respectively) found statistically inferior as compared to other treatments. The application of biofertilizers and organic manures in combination with inorganic fertilizers enhances the fertility and moisture retention capacity of soil increased the availability of nutrients and their translocation to plants favored the plant growth which might have contributed to the increase in number of leaves and leaf area of plant. These findings are in line with the results obtained by Sharma *et al.* (2017) [10] and Chaupoo and Kumar (2020) [3].

Analysis of variance showed that the treatment supplied with 75% RDF + 25% FYM + Ghanjeevamrit + Azotobacter + PSB (T7) had maximum number of branches (22.60 and 26.47, primary and secondary, respectively) which was found at par with 75% RDF + 25% FYM + Ghanjeevamrit, 100% RDF (Inorganic), 100% RDF through FYM + Ghanjeevamrit + Azotobacter + PSB, 50% RDF + 50% FYM + Ghanjeevamrit + Azotobacter + PSB and 50% RDF + 50% FYM + Ghanjeevamrit and significantly superior than rest of the treatments. Higher number of secondary branches $plant^{-1}$ was recorded when the plants were supplied with biofertilizers as well as organic manures combined with synthetic fertilizers might be due to enhancement of soil fertility and moisture retention capacity of soil, favoring the plant growth which might have contributed to the betterment of plant physiological process and ultimately development of plant. Better results from ghanjeevamrit might be due the reason that it contains nitrogen and phosphorus which improves structural parameters. Our results are in agreement with the findings of Singh *et al.* (2015) [11] and Chaupoo and Kumar (2020) [3].

75% RDF + 25% FYM + Ghanjeevamrit + Azotobacter + PSB (T7) recorded minimum days for first flower bud appearance and 50% flowering (48.79 and 57.97 days, respectively) which were at par with 75% RDF + 25% FYM + Ghanjeevamrit, 100% RDF (Inorganic), 100

% RDF through FYM + Ghanjeevamrit + Azotobacter + PSB, 50% RDF + 50% FYM + Ghanjeevamrit + Azotobacter + PSB and 50% RDF + 50% FYM + Ghanjeevamrit and better over rest of the treatments. 50% RDF + Ghanjeevamrit (T9) had significantly maximum days for first flower bud appearance as well as 50% flowering (59.31 and 71.25 days, respectively) as compared to other treatments. The beneficial effect on earliness in bud appearance and flowering might be due to early breaking of apical dominance followed by easy and better translocation of nutrients to the flowers, better plant growth by the increased availability of nutrients and accelerated mobility of photosynthates from source to sink as influenced by the growth hormones released or synthesized from organic manures and bio-fertilizers. The results were in close conformity with Kumar *et al.* (2016) [7] and Chaupoo and Kumar (2020) [3].

The maximum number of flowers $plant^{-1}$, flower diameter, fresh weight of flower, period of flowering, flower yield $plot^{-1}$ and ha^{-1} (53.20, 55.92 mm, 320.26 g $plant^{-1}$,61.98 days, 8.01 kg $plot^{-1}$ and 200.17 q ha^{-1}, respectively) were recorded with 75% RDF + 25% FYM + Ghanjeevamrit + Azotobacter + PSB (T7) followed by 75% RDF + 25% FYM + Ghanjeevamrit, 100% RDF (Inorganic), 100% RDF through FYM + Ghanjeevamrit + Azotobacter + PSB, 50% RDF + 50% FYM + Ghanjeevamrit + Azotobacter + PSB and 50% RDF + 50% FYM + Ghanjeevamrit but significantly higher than rest of the treatments. 50% RDF + Ghanjeevamrit (T9) had significantly inferior results as compared to other treatments. Plant nutrient supplied through organic sources had profound effect on growth of the crop either by acceleration of respiratory process with increasing cell probability and hormonal growth action or by combination of all these processes and ultimately resulted in higher flower quality and yield. The advantages of this technique lead to availability of nutrients through nitrogen fixation in soil, increase the resistance of plants to biotic and abiotic stresses, phosphorus solubilization and growth regulators production such as IAA and GA3. Patel *et al.* (2017) [9] and Upadhya *et al.* (2022) [12] also reported almost similar results.

Maximum net return was recorded under treatment 75% RDF + 25% FYM + Ghanjeevamrit + Azotobacter + PSB (T7) (₹ 416829.95 ha^{-1}) followed by 75% RDF + 25% FYM + Ghanjeevamrit (₹ 408973.29 ha^{-1}), 100% RDF (Inorganic) (₹ 409170.48 ha^{-1}), 100% RDF through FYM + Ghanjeevamrit + Azotobacter + PSB (₹ 375677.96 ha^{-1}) and 50% RDF + 50% FYM + Ghanjeevamrit + Azotobacter + PSB (₹ 373790.05 ha^{-1}) and were significantly superior over other treatments. While the highest B: C ratio (2.41) was obtained from the treatment supplied with 100% RDF through inorganics (T1), closely followed by 75% RDF + 25

% FYM + Ghanjeevamrit + Azotobacter + PSB (4.99) and 75% RDF + 25% FYM + Ghanjeevamrit (4.93). However, the minimum net return (₹ 206203.18 ha^{-1}) and B: C ratio (2.82) were obtained under 50% RDF + Ghanjeevamrit (T9). It is also worth mentioning that inoculation of biofertilizers along with farmyard manure and inorganic fertilizers help in achieving significant flower yield as compared to all the treatments. Thus, reducing the dose of inorganic fertilizers by the integration of biofertilizers (*Azotobacter* and phosphorus solubilizing bacteria) and organic manure (farmyard manure and ghanjeevamrit) is advantageous regarding the net realization under marigold cultivation. Cost of cultivation having the marginal difference amongst the treatments and it determined the B: C ration. In all the treatments B: C ration reflectsthe profitability of the experiment. The maximum benefit: cost ratio under inorganic fertilizers might be due to production of maximum number of quality flower under this treatment, fetching better price as well as lower cost of synthetic fertilizers thus increasing benefit: cost ratio as compared to other treatments. Similar result also result was also reported by Jadhav *et al.* (2014) [5] and Malik *et al.* (2021) [9].

Table 1: Effect of integrated nutrient management practices on growth parameters of marigold

Treatments	Treatment details	Plant height Cm	Plant spread (cm)		Number of leaves Plant^{-1}	Leaf area (cm^2)	Number of branches plant^{-1}	
			E-W	N-S			Primary branches	Secondary branches
T1	100% RDF (Inorganic)	96.13	61.87	59.80	38.76	73.78	21.80	25.47
T2	100% RDF through FYM + Ghanjeevamrit + Azotobacter + PSB	94.33	60.80	58.60	38.51	72.10	21.60	25.15
T3	75% RDF + 25% FYM	87.67	56.47	54.87	35.11	67.23	20.13	23.78
T4	75% RDF + Ghanjeevamrit	78.33	53.27	51.53	34.27	66.05	19.53	21.00
T5	75% RDF + Azotobacter + PSB	79.33	53.73	52.33	34.66	66.32	19.87	21.18
T6	75% RDF + 25% FYM +Ghanjeevamrit	97.27	62.27	60.07	39.33	74.29	22.00	26.14
T7	75% RDF + 25% FYM + Ghanjeevamrit + Azotobacter + PSB	99.60	63.80	61.33	39.84	75.67	22.60	26.47
T8	50% RDF + 50% FYM	86.93	55.80	54.73	34.91	67.00	19.93	23.65
T9	50% RDF + Ghanjeevamrit	71.67	51.73	48.93	33.14	64.32	17.73	20.11
T10	50% RDF + Azotobacter + PSB	72.00	52.27	49.73	33.65	64.99	18.13	20.72
T11	50% RDF + 50% FYM + Ghanjeevamrit	92.67	58.47	57.00	36.72	69.44	20.20	24.14
T12	50% RDF + 50% FYM + Ghanjeevamrit + Azotobacter + PSB	93.93	59.27	57.33	37.11	70.78	20.33	24.32
S.Em ±		4.07	2.31	2.05	1.33	2.40	0.78	0.89
CD (P=0.05)		11.94	6.76	6.00	3.91	7.05	2.30	2.61

Table 2: Effect of integrated nutrient management practices on floral characters of marigold

S.no	Treatment	Days taken to first flower bud appearance (days)	Days taken to 50% flowering (days)	Number of flowers plant'	Diameter of flower (mm)	Period of flowering (days)
T1	**100%** RDF (Inorganic)	50.56	60.84	51.67	52.67	58.63
T2	100% RDF through FYM + Ghanjeevamrit + Azotobacter + PSB	**51.99**	61.24	5033	51.51	5745
T3	75% RDF + 25% FYM	54.82	65.56	45.93	48.90	53.81
T4	75% RDF + Ghanjeevamrit	57.69	68.32	42.87	47.88	51.22
T5	75% RDF + Azotobacter + PSB	57.32	67.25	43.73	48.28	51.44
T6	75% RDF + 25% FYM + Ghanjeevamrit	49.14	58.88	52.00	53.95	60.76
T7	IS% KIX. + 25% k YM + Ghanjeevamrit + Azotobacter + PSB	48.79	57.97	53.20	55.92	61.98
T8	50% RDF + 50% FYM	55.14	65.78	44.20	48.78	53.16
T9	50% RDF + Ghanjeevamrit	59.31	71.25	41.67	46.75	48.23
T10	Tie 50% RDF + Azotobacter + PSB	58.94	70.54	41.87	47.80	49.76
T11	Ti, 50% RDF + 50% FYM + Ghanjeevamrit	53.44	62.91	47.87	49.11	55.92
T12	SO%RI& + SO% k YM + Ghanjeevamrit + Azotobacter + PSB	52.56	62.49	48.20	50.93	56.88
S.E(n)$^{-1}$		2.02	2.39	1.89	1.84	2.03
CD (P1.05)		5.93	7.02	5.53	5.39	5.97

Table 3: Effect of integrated nutrient management practices on yield and economics of marigold

S.no	Treatment	Fresh weight of Flower (g plant)	Yields of marigold (kg plot^{-1})	(kg plot^{-1})	Net return (₹ ha^{-1})	Benefit Ti cost Rs
T1	100% RDF (Inorganic)	310.35	7.76	193.97	409170.48	5.40
T2	100% RDF through FYM + Ghanjeevamrit + Azotobacter + PSB	305.78	7.64	191.11	375677.96	3.68
T3	75% RDF + 25% FYM	244.82	6.12	153.02	300616.00	3.67
T4	75% RDF + Ghanjeevamrit	210.05	5.25	131.28	253275.37	3.38
T5	75% RDF + Azotobacter + PSB	218.23	5.46	136.39	266400.79	3.57
T6	75% RDF + 25% FYM + Ghanjeevamrit	314.81	7.87	196.76	408973.29	4.93
T7	75% RDF + 25% FYM + Ghanjeevamrit + Azotobacter + PSB	320.26	8.01	200.17	416829.95	4.99
T8	50% RDF + 50% FYM	226.75	5.67	141.72	266196.93	3.02
T9	50% RDF + Ghanjeevamrit	178.75	4.47	111.72	206203.18	2.82
T10	50% RDF + Azotobacter + PSB	188.82	4.72	118.01	222275.47	3.06
T11	50% RDF + 50% FYM + Ghanjeevamrit	291.62	7.29	182.26	366558.39	4.11
T12	50% RDF + 50% FYM + Ghanjeevamrit	296.67	7.42	185.42	373790.05	4.16
	SE(m) ±	9.97	0.24	6.29	15723.38	0.19
	CD (*P*=0.05)	29.23	0.70	18.45	46115.08	0.56

Conclusion

From the present study, it can be conclude that treatment 75% RDF + 25% FYM + Ghanjeevamrit + Azotobacter + PSB can be used effectively in marigold, to benefit the crop and improve soil health in relation to physical, chemical and biological properties of soil. Although there were increase in yield under T7 and T6 in comparison to T1 but this improvement was not found to be significant. But still farmers are recommended to go for organic farming for sustainable horticulture. Since, treatments T7 and T6 were outstanding in Net gain but from economic point of view treatment T7 stood promising to achieve an entire income of ₹ 7857 over T6 by merely spending an extra amount of ₹ 660 in use of Azotobacter and PSB in this treatment. Farmers can adopt T7 and T6 treatments for commercial cultivation as there is a net saving of 25% of chemical fertilizer.

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