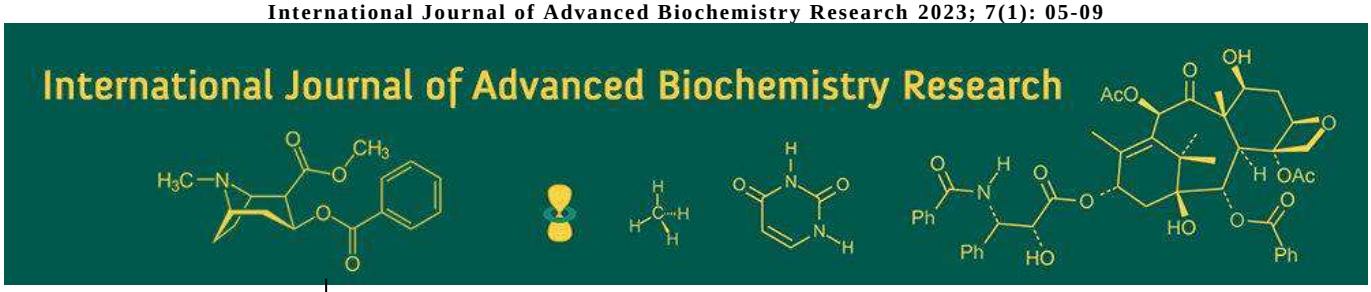

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Mukesh Kumar
Research Scholar, Faculty of Agriculture Sciences, Bhagwant University, Ajmer, Rajasthan, India

Bindhya Prashad
Research Scholar, Faculty of Agriculture Sciences, Bhagwant University, Ajmer, Rajasthan, India

Corresponding Author:
Mukesh Kumar
Research Scholar, Faculty of Agriculture Sciences, Bhagwant University, Ajmer, Rajasthan, India

Effect of integrated nutrient management on flowering and yield attributing traits of marigold (*Tagetes erecta* L.) under agro-climatic conditions of Ajmer zone

Mukesh Kumar and Bindhya Prashad

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Abstract
The current study was steered at Bhagwant University Ajmer, Rajasthan during the Rabi season of years 2019-20 and 2020-21 to find out the combined application of different organic and inorganic sources of nutrients on flowering behaviour and yield attributing traits of Marigold (*Tagetes erecta* L.) under Agro-climatic conditions of Ajmer Zone. Total ten treatments were used in Randomized Block Design (RBD) and replicated three times. The treatments namely T_1- Control, T_2- 100% RDF (N:P: K @ 120:80:60 kg/ha), T_3-100% RDF + 25% VC, T_4- 100% RDF + 25% FYM, T_5- 75% RDF + FYM + Biofertilizers, T_6- 75% RDF + VC + Biofertilizers, T_7- 75% RDF + FYM + VC + Biofertilizers, T_8- 50% RDF + FYM + VC + Biofertilizers, T_9- 50% RDF + FYM + Biofertilizers and T_{10}- 50% RDF + VC + Biofertilizers. Total 30 treatment combinations were formulated in present experiment. During the experimentation, observations were recorded on various flowering and yield attributing parameters like days taken to first bud initiation, days taken for opening of flower bud, days taken to first flowering, days taken to 50% flowering, flower stalk length, diameter of flower, number of flowers per plant, fresh weight of flower, flower yield per plant, flower yield per plot, flower yield (q/ha) and B:C ratio of applied treatments. However, the maximum flowering and yield were found in T_7- 75% RDF + FYM + VC + Biofertilizers as compared to T_8- 50% RDF + FYM + VC + Biofertilizers.

Keywords: Integrated nutrient management, *Tagetes erecta* L., Rabi season

Introduction
Marigold is one of the most significant commercial flower crops farmed worldwide, including in India, marigolds account for more than half of the country's production of loose flowers. (Sreekanth *et al.*, 2006) [17]. It is a member of the Asteraceae family and is endemic to Central and South America, particularly Mexico. Its genus name is *Tagetes*. However, the cultivation of *Tagetes erecta* L. commonly known as African marigold and *T. patula* L. the French marigold dominates. Marigold holds a distinctive place in society due to its toughness, ease of cultivation, wide range of soil and climate adaptation, and ease of transportation. Growers and traders are drawn to it by its propensity for prolific blossoming, short time required to produce a marketable flower, wide range of attractive colour, size, and form, and maintaining quality. It plays a crucial part in the creation of garlands, bouquets, and floral décor for weddings and other celebrations. Due to its considerable potential for value addition, it has also grown in importance in the industrial sector. In integrated nutrient management techniques, inorganic fertilizers are utilised less, soil contamination is reduced, at least in part, as a result of the use of high fertiliser doses, and natural resources are protected (Natsheh *et al.*, 2014) [8]. The production is decreased as a result of the continual and unbalanced application of fertilizers that harm the soil, ground water, air quality, and phosphorus deposition in the soil (Savci, 2012) [12]. Therefore, using balanced nutrient management is crucial for crop productivity. Because flowers are an expensive and specialised material, blooming plants need nutrients for optimum growth, development, and flower production with high-quality products. It can be done by strategically combining different nutrients. Efficient and prudent use of chemical fertilizers in conjunction with organic manure is essential not only for achieving higher yields per unit area on a sustainable basis, but also for conserving energy and avoiding environmental quality issues. FYM feeds the plants the nutrients they require.

Apart from that, it supplies critical macro elements such as nitrogen, phosphorus, and potassium, and vermicompost provides the necessary nutrients to the plants. It gives the plants the essential macro elements like nitrogen and phosphorus. They also contain chemicals that control plant growth, such as NAA, Cytokinin, Gibberellins, etc (Song *et al*., 2017) [16].

Materials and Methods

The present experiment was carried out at Bhagwant University Ajmer, India during the year 2019-20 and 2020-21 during the winter season. The experimental site is situated at an elevation of 480.65 meters above sea level, Ajmer has a subtropical steppe climate. The districts yearly temperature is 29.3^{0}C and 3.33% higher than India's averages. Ajmer is typically receiving about 75.27 mm of precipitation and has 70.19 rainy days annually. Total ten treatments were used in Randomized Block Design (RBD) and replicated three times. The treatments namely T_1- Control, T_2- 100% RDF (N:P: K @ 120:80:60 kg/ha), T_3- 100% RDF + 25% VC, T_4- 100% RDF + 25% FYM, T_5- 75% RDF + FYM + Biofertilizers, T_6- 75% RDF + VC + Biofertilizers, T_7- 75% RDF + FYM + VC + Biofertilizers, T_8- 50% RDF + FYM + VC + Biofertilizers, T_9- 50% RDF + FYM + Biofertilizers and T_{10}- 50% RDF + VC + Biofertilizers. Total 30 treatment combinations were formulated in present experiment. During the first-year marigold seeds were sown on raised beds. The soil of bed was prepared to fine filth with combination of well decomposed FYM (20 kg) and (300 g) DAP per bed. The line sowing of seeds at apart of 4-5 cm. The seed beds were enclosed with a mixture of garden soil and coarse sand. The nursery beds were sheltered by the paddy straw after sowing. Firstly, watering was done with watering can at alternate days. The seeds germinated within 4-5 days of sowing and there after mulch cover was removed. Hardening of the seedlings were done by withdrawing the watering 2-3 days before lifting the seedlings. However, watering was done in forenoon to facilitate smooth lifting of seedlings. During the experimentation, observations were recorded on various flowering and yield attributing parameters like days taken to first bud initiation, days taken for opening of flower bud, days taken to first flowering, days taken to 50% flowering, flower stalk length, diameter of flower, number of flowers per plant, fresh weight of flower, flower yield per plant, flower yield per plot, flower yield (q/ha) and B:C ratio.

Result and Discussion

Effect of Different Organic and Inorganic sources of Nutrients on flowering behaviour of Marigold

Minimum days taken to first bud initiation (34.98) and minimum days taken to first bud opening (41.87) were observed in T7 - 75% RDF + FYM + VC + Biofertilizers, followed by T8- 50% RDF + VC + Biofertilizers treatment during two years separately with pooled mean data. This may be ascribed to the easy uptake of nutrients and simultaneous transport of growth promoting substances like auxins, gibberellins, vitamins and organic acids produced by bio-fertilizers to the axillary buds resulting in earliness to reach harvesting stage. Similar result has been obtained by Shaikh *et al.,* (2018) [13], Yadav *et al*., (2018) [20] and Chaupoo *et al.,* (2020) [4]. The minimum days taken to first flowering in plants (43.78) and minimum days taken to 50% flowering in plants (46.78) were observed in T7 - 75% RDF + FYM + VC + Biofertilizers, followed by T8- 50% RDF + VC + Biofertilizers treatment 46.04 and 48.27 during two years separately with pooled mean data. The earliness in the first flowering through the application of bio-fertilizers and inorganic sources of nutrients may be favourable response of bio-inoculation, which showed the nutrients availability to the plants by edition of atmospheric nitrogen to the soil encouraged more vegetative growth through encouragement of plant growth endorsing the substances such as Auxins, gibberellins, vitamins and organic acid. These results are also in close conformity with the finding of Patel *et. al.,* (2018) [10], Borah *et al.,* (2019) [2] and Kaushik *et al.,* (2020) [5]. lowest flower stalk length in plants (5.44 cm) and maximum diameter of flower in plants (5.16 cm) was observed in T7 - 75% RDF + FYM + VC + Biofertilizers, followed by T8- 50% RDF + VC + Biofertilizers treatment 6.03 cm and 4.99 cm. The similar findings were also noted by Wani *et al,* (2017) [19], Sharma *et al.,* (2017) [14], Bose *et al.,* (2018) [3], Yadav *et al.,* (2018) [20] and Chaupoo *et al.,* (2020) [4]. The present experiment concluded that an application of 75% RDF + FYM + VC + Biofertilizers per hectare was found to be most effective in terms of growth parameters and flowering behaviour of African marigold treatments in a profitable manner. As a result, a dose of 75% RDF + FYM + VC + Biofertilizers was proposed for commercial growing of African marigold under Agro-climatic conditions of Ajmer zone in Rajasthan.

Effect of Different Organic and Inorganic sources of Nutrients on yield attributing traits of Marigold

The pooled mean data of the both of the years clearly shows that the maximum number of flowers per plant (58.79) was observed in T7 - 75% RDF + FYM + VC + Biofertilizers, followed by T10 - 50% RDF + FYM + VC + Biofertilizers, treatment (53.95). This might be due to nitrogen and phosphorus fertilization in combination of bio-fertilizers, FYM and vermicompost proved to be helpful to fix the atmospheric nitrogen and solubilize fixed phosphorus in soil and it also secrete growth substances like auxins, which stimulated the plant metabolic activities and photosynthetic efficacy leading healthier growth and development of plant. These results are also in close conformity with the finding of Singh *et al*., (2016) [15], Patel *et al*., (2018) [10] and Tiwari *et al.,* (2018) [18] in African marigold. The pooled mean data of the both of the years clearly shows that the maximum fresh weight of flowers (4.84 g) was observed in T7 - 75% RDF + FYM + VC + Biofertilizers, followed by T10 - 50% RDF + FYM + VC + Biofertilizers treatment (4.32 g). The significant increase in fresh weight of flower might be due to assimilation of nitrogen and phosphorus from vermicompost and 75% nitrogen and phosphorus in association with more nitrogen fixing and phosphorus solubilizing proficiency and secretion of hormones by the cultures. Enhancement in fresh weight flower might be due to cell elongation in the flower. Similar result was recorded by Pandey *et al*., (2018) [9] and Tiwari *et al*., (2018) [18] in African marigold. The pooled mean data of the both of the years clearly shows that the maximum flower yield per plant (284.82 g) was observed in T7 - 75% RDF + FYM + VC + Biofertilizers, followed by T10 - 50% RDF + FYM + VC + Biofertilizers treatment (233.01 g). The increase in flower yield might be due to active and rapid multiplication of bacteria especially in rhizosphere creating favourable

condition for nitrogen fixation and phosphorus solubilization at higher rate through nitrogen supply by nitrogenous fertilizers and supply of bio-fertilizers which leads to the robust growth and maximum increase in flowering span, flower diameter and flower number. These findings were in accordance with the result of Yadav *et al.*, (2018) [20], Patel *et al.,* (2018) [10], Kumura *et al.,* (2019) [7] and Chaupoo *et al.,* (2020) [4] in African marigold. In the present investigation, significantly higher flower yield per plot was observed under the combined application of different doses of NPK and organic manures (FYM and Vermicompost) along with bio-fertilizers. The pooled mean data of the both of the years clearly shows that the maximum flower yield per plot (7.11 kg) was observed in T7 - 75% RDF + FYM + VC + Biofertilizers, followed by T10 - 50% RDF + FYM + VC + Biofertilizers treatment (5.82 kg). It might be due to supply of nitrogenous fertilizers along with other nutrients, bacterial secretion, hormone production and supply of antibacterial and antifungal compounds, which were favourable for growth and ultimately increased yield. The similar findings were also noted by Aslam *et al.,* (2016) [1], Borah *et al.,* (2019) [2] and Chaupoo *et al.,* (2020) [4] in African marigold. The pooled mean data of the both of the years clearly shows that the maximum flower yield per hectare (316.22 q/ha) was observed in T7 - 75% RDF + FYM + VC + Biofertilizers, followed by T10 - 50% RDF + FYM + VC + Biofertilizers treatment (258.88 q/ha). This increase in yield might be due to active and rapid multiplication of bacteria especially in rhizosphere creating favourable condition for nitrogen fixation and phosphorus solubilization at higher rate through nitrogen supply by nitrogenous fertilizers, organic manures (FYM and vermicompost) and bio-fertilizers which leads to the bacterial secretion, hormone production and supply of antibacterial and antifungal compounds, which were favourable for growth and yield. These findings were in accordance with the result of Wani *et al*., (2017) [19], Rolaniya *et al.,* (2017) [11], Patel *et al*., (2018) [10] and Chaupoo *et al*., (2020) [4] in African Marigold. The present experiment concluded that an application of 75% RDF + FYM + VC + Biofertilizers per hectare was found to be most effective in terms of flowering behaviour and yield attributing characters of African marigold in a profitable manner. As a result, a dose of 75% RDF + FYM + VC + Biofertilizers was proposed for commercial growing of African marigold under Agro-climatic conditions of Ajmer zone in Rajasthan.

Table 1: Effect of Integrated Nutrient Management on flowering of Marigold (*Tagetes erecta* L.) under Agro-climatic conditions of Ajmer Zone

Treatments	Days to first bud initiation			Days taken to first bud opening			Days taken to first flowering		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T1	45.00	44.58	44.79	51.43	51.98	51.70	54.23	55.45	54.84
T2	43.11	43.00	43.05	50.22	50.36	50.29	53.63	54.27	53.95
T3	42.15	42.75	42.45	49.11	49.35	49.23	52.21	53.34	52.77
T4	41.66	41.23	41.44	48.22	48.78	48.50	51.33	52.43	51.88
T5	39.00	39.32	39.16	46.13	45.32	45.72	48.52	49.43	48.97
T6	38.65	39.00	38.82	45.44	44.00	44.72	48.67	49.32	48.99
T7	35.84	34.12	34.98	42.20	41.55	41.87	44.32	43.25	43.78
T8	36.88	35.25	36.06	43.48	42.72	43.10	46.25	45.83	46.04
T9	37.65	37.65	37.65	43.36	44.29	43.82	47.33	46.65	46.99
T10	40.23	40.89	40.56	47.25	46.32	46.78	49.32	48.23	48.77
S.Em.±	0.36	0.24		0.27	0.23		0.32	0.27	
C. D. at 5% of level	1.04	0.71		0.77	0.66		0.92	0.79	

Table 2: Effect of Integrated Nutrient Management on flowering of Marigold (*Tagetes erecta* L.) under Agro-climatic conditions of Ajmer Zone

Treatments	Days taken to 50% flowering			Flower stalk length (cm)			Diameter of Flower (cm)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T1	58.62	59.23	58.92	8.65	8.17	8.41	1.72	1.83	1.77
T2	57.64	57.32	57.48	8.33	7.95	8.14	2.14	2.23	2.18
T3	56.20	56.03	56.11	7.85	7.45	7.65	2.45	2.47	2.46
T4	55.12	54.31	54.71	7.00	7.85	7.42	3.45	3.67	3.56
T5	52.31	53.21	52.76	6.55	6.32	6.43	3.85	3.93	3.89
T6	53.65	53.65	53.65	6.88	6.85	6.86	4.36	4.23	4.29
T7	46.32	47.25	46.78	5.65	5.23	5.44	5.11	5.21	5.16
T8	48.55	48.00	48.27	5.95	6.11	6.03	5.00	4.98	4.99
T9	49.22	49.35	49.28	6.39	6.47	6.43	4.58	4.21	4.39
T10	51.44	52.32	51.88	6.22	6.43	6.32	4.81	4.77	4.79
S.Em.±	0.24	0.18		0.14	0.12		0.07	0.05	
C. D. at 5% of level	0.69	0.53		0.40	0.34		0.20	0.14	

Table 3: Effect of Integrated Nutrient Management on yield attributing traits of Marigold (*Tagetes erecta* L.) under Agro-climatic conditions of Ajmer Zone

Treatments	Number of Flowers per Plant			Fresh Weight of Flowers (g)			Flower Yield per Plant (g)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T1	26.46	25.41	25.93	2.73	2.47	2.60	72.23	62.76	67.49
T2	39.25	40.52	39.88	3.22	3.32	3.27	126.38	134.52	130.45
T3	40.31	41.44	40.87	3.41	3.34	3.37	137.45	138.4	137.92
T4	42.38	43.62	43.00	3.57	3.62	3.59	151.29	157.9	154.59
T5	46.23	46.47	46.35	3.62	3.55	3.58	167.35	164.96	166.15
T6	49.22	50.77	49.99	3.85	3.93	3.89	189.49	199.52	194.50
T7	58.47	59.11	58.79	4.87	4.82	4.84	284.74	284.91	284.82
T8	51.82	52.18	52.00	4.10	4.15	4.12	212.46	216.54	214.50
T9	52.32	53.21	52.76	4.22	4.18	4.20	220.79	222.41	221.60
T10	53.37	54.54	53.95	4.43	4.21	4.32	236.42	229.61	233.01
S.Em.±	0.26	0.22		0.06	0.04		2.84	1.82	
C. D. at 5% of level	0.76	0.63		0.16	0.10		8.22	5.25	

Table 4: Effect of Integrated Nutrient Management on yield attributing traits and Benefit Cost Ratio of Marigold (*Tagetes erecta* L.) under Agro-climatic conditions of Ajmer Zone

Treatments	Flower Yield per Plot (Kg)			Flower Yield (q/ha)			Benefit Cost Ratio		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T1	1.8	1.56	1.68	80.00	69.33	74.66	1.77	1.55	1.66
T2	3.15	3.36	3.25	140.00	149.33	144.66	2.88	2.85	2.86
T3	3.43	3.46	3.44	152.44	153.77	153.10	2.95	2.98	2.96
T4	3.78	3.94	3.86	168.00	175.11	171.55	3.27	3.21	3.24
T5	4.18	4.12	4.15	185.77	183.11	184.44	3.25	3.34	3.29
T6	4.73	4.98	4.85	210.22	221.33	215.77	3.47	3.85	3.66
T7	7.11	7.12	7.11	316.00	316.44	316.22	4.86	4.12	4.49
T8	5.31	5.41	5.36	236.00	240.44	238.22	3.67	3.83	3.75
T9	5.51	5.56	5.53	244.88	247.11	245.99	3.88	3.75	3.81
T10	5.91	5.74	5.82	262.66	255.11	258.88	4.62	3.53	4.07
S.Em.±	0.07	0.05		3.16	2.02		0.13	0.17	
C. D. at 5% of level	0.21	0.13		9.15	5.86		0.37	0.41	

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