International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2023; SP-7(1): 01-04
www.biochemjournal.com
Received: 01-11-2022
Accepted: 05-12-2022

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Impact of different organic and inorganic sources of nutrients on vegetative growth of marigold (*Tagetes erecta* L.) under agro-climatic conditions of Ajmer zone

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DOI: https://doi.org/10.33545/26174693.2023.v7.i1a.162

Abstract
The present investigation was conducted 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 growth behaviour 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 growth characters like plant height, number of primary branches, number of secondary branches, plant spread and stem diameter at various successive stages of growth. Though, the maximum growth and flowering was found in T_7- 75% RDF + FYM + VC + Biofertilizers as compared to T_8- 50% RDF + FYM + VC + Biofertilizers.

Keywords: Sources of nutrients, *Tagetes erecta* L., randomized block design (RBD)

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) [16]. 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) [11]. 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) [15].

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 °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 growth parameters like plant height, number of primary branches, number of secondary branches, plant spread and stem diameter at various successive stages of growth i.e., 30, 60 and 90 days after transplanting.

Result and Discussion

Effect of Different Organic and Inorganic sources of Nutrients on growth characters of Marigold

The maximum plant height (30.53, 55.09 and 66.67 cm) at 30, 60 and 90 days after transplanting was recorded under the treatment T7 - 75% RDF + FYM + VC + Biofertilizers followed by treatment T10- 50% RDF + FYM + VC + Biofertilizers, during two years separately with pooled mean data. Such effect may be recognized to the fact as the higher level of nitrogen and other nutrients are the major requirement for plant growth. Nitrogen helped to activate the cell formation and cell multiplication resulting in superior plant growth. These increases in cell might be due to the presence of some Auxins like NAA and IAA present in vermicompost. These findings are in conformity with the findings of Kumawat *et al*., (2017) [6], Shaikh *et al*., (2018) [12] and Yadav *et al*., (2018) [18]. The maximum number of primary branches per plant (10.83, 14.44 and 18.80) at 30, 60 and 90 days after transplanting was recorded with T7 - 75% RDF + FYM + VC + Biofertilizers, followed by treatment T6- 75% RDF + VC + Biofertilizers, while, the maximum number of secondary branches per plant (10.74, 22.83 and 36.04) at 30, 60 and 90 days after transplanting was recorded with T7 - 75% RDF + FYM + VC + Biofertilizers, during two years separately with pooled mean data. The reason for maximum number of primary and secondary branches per plant was might be due to maximum utilisation of nitrogen, phosphorus and potassium from soil and available nutrients of vermicompost with combination of biofertilizers. Biofertilizers are microbial inoculants which are capable in nitrogen fixation, phosphorus solubilising and decomposing organic matter at a faster rate and thus help in improving the soil fertility and boosting crop productivity. These results confirm the findings of Sharma *et al*., (2017) [13], Tiwari *et al*., (2018) [17] and Kumura *et al*., (2019) [7] in African marigold. The maximum plant spread (21.80, 27.83 and 34.94 cm^2) at 30, 60 and 90 days after transplanting was recorded with T7 - 75% RDF + FYM + VC + Biofertilizers, followed by treatment T6- 75% RDF + VC + Biofertilizers. During two years separately with pooled mean data. The spread might be due to the high availability of major nutrients and providing growth substances, such as NAA, GA and cytokinin's. The results are in accordance with the report of Kumar *et al*., (2015) [5], Singh *et al*., (2016) [14] Bose *et al*., (2018) [2] and Patel *et al*., (2018) [10]. The maximum stem diameter of plant (1.43, 1.60 and 3.32 cm) at 30, 60 and 90 days after transplanting was recorded with T7 - 75% RDF + FYM + VC + Biofertilizers, followed by treatment T8- 50% RDF + VC + Biofertilizers. While the minimum stem diameter (0.51, 0.88 and 1.38 cm) at 30, 60 and 90 days after transplanting was observed under control during two years separately with pooled mean data. Similar findings were also noted by Pandey *et al*., (2018) [9], Borah *et al*., (2019) [1], Kaushik *et al*., (2020) [4] and Chaupoo *et al*., (2020) [3]. The current experimentation concluded that an application of 75% RDF + FYM + VC + Biofertilizers per hectare was found to be most effective in terms of growth parameters 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.

Table 1: Impact of Different Organic and Inorganic sources of Nutrients on Plant height at various successive stages of growth

Treatments	Plant height (cm) at various successive stages of growth								
	30 DAT			60 DAT			90 DAT		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T1	18.54	16.26	17.40	39.34	38.48	38.91	49.23	47.57	48.40
T2	21.34	20.67	21.00	42.44	43.23	42.83	51.33	50.19	50.76
T3	24.23	21.45	22.84	44.36	43.56	43.96	54.65	52.44	53.54
T4	24.78	24.58	24.68	44.23	45.11	44.67	55.54	56.23	55.88
T5	27.76	28.47	28.11	48.45	47.42	47.93	56.89	57.65	57.27
T6	27.11	27.56	27.33	49.67	48.63	49.15	59.67	60.43	60.05
T7	29.64	31.42	30.53	55.57	54.62	55.09	66.32	67.43	66.87
T8	26.43	25.45	25.94	46.51	46.67	46.59	58.55	57.76	58.15
T9	24.42	26.54	25.48	44.78	46.56	45.67	58.39	60.56	59.47
T10	29.61	30.13	29.87	53.22	51.34	52.28	63.51	61.89	62.70
S.Em.±	0.55	0.46		0.54	0.33		0.69	0.42	
C. D. at 5% of level	1.60	1.33		1.58	0.95		2.00	1.23	

Table 2: Impact of Different Organic and Inorganic sources of Nutrients on Number of Primary Branches at various successive stages of growth

Treatments	Number of Primary Branches at various successive stages of growth								
	30 DAT			60 DAT			90 DAT		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T1	4.35	5.32	4.83	8.58	8.18	8.38	10.11	11.27	10.69
T2	6.45	5.56	6.00	9.39	10.00	9.69	12.32	13.41	12.86
T3	7.78	6.78	7.28	10.32	9.82	10.07	13.65	14.47	14.06
T4	8.34	7.76	8.05	11.35	11.23	11.29	15.20	16.22	15.71
T5	9.11	8.63	8.87	12.52	12.33	12.42	16.21	17.64	16.92
T6	9.78	8.76	9.27	12.60	13.54	13.07	18.85	17.27	18.06
T7	11.22	10.44	10.83	13.31	15.58	14.44	18.28	19.32	18.80
T8	8.40	9.12	8.76	11.54	13.27	12.40	15.32	15.20	15.26
T9	8.11	7.89	8.00	12.77	13.25	13.01	15.00	14.25	14.62
T10	7.22	6.92	7.07	9.35	10.35	9.85	13.32	12.53	12.92
S.Em.±	0.28	0.20		0.33	0.27		0.55	0.30	
C. D. at 5% of level	0.81	0.58		0.95	0.77		1.58	0.88	

Table 3 Impact of Different Organic and Inorganic sources of Nutrients on Number of Secondary Branches at various successive stages of growth.

Treatments	Number of Secondary Branches at various successive stages of growth								
	30 DAT			60 DAT			90 DAT		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T1	4.43	3.65	4.04	9.32	8.25	8.78	16.32	17.85	17.08
T2	8.63	9.23	8.93	14.32	16.32	15.32	22.32	23.25	22.78
T3	7.12	7.85	7.48	14.52	14.25	14.38	23.65	24.22	23.93
T4	7.14	8.65	7.89	14.65	13.52	14.08	24.65	25.65	25.15
T5	8.38	8.15	8.26	14.32	16.23	15.27	25.47	25.22	25.34
T6	9.74	9.23	9.48	20.22	21.33	20.77	31.33	32.42	31.87
T7	10.23	11.25	10.74	22.32	23.35	22.83	35.42	36.67	36.04
T8	8.55	9.65	9.10	18.98	16.35	17.66	28.32	29.32	28.82
T9	7.95	8.56	8.25	17.55	21.32	19.43	29.31	30.21	29.76
T10	6.68	7.84	7.26	18.32	16.35	17.33	27.82	28.32	28.07
S.Em.±	0.32	0.22		0.70	0.58		0.33	0.14	
C. D. at 5% of level	0.93	0.64		2.01	1.69		0.96	0.41	

Table 4: Impact of Different Organic and Inorganic sources of Nutrients on Plant Spread at various successive stages of growth.

Treatments	Plant Spread (cm^2) at various successive stages of growth								
	30 DAT			60 DAT			90 DAT		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T1	9.23	10.32	9.77	11.29	12.02	11.65	18.22	18.72	18.47
T2	13.32	14.58	13.95	17.32	18.61	17.96	26.32	26.32	26.32
T3	11.33	12.65	11.99	18.65	19.62	19.13	27.25	28.28	27.76
T4	15.25	14.23	14.74	19.63	20.30	19.96	29.32	28.32	28.82
T5	14.52	15.65	15.08	22.28	22.54	22.41	28.32	30.58	29.45
T6	16.32	17.85	17.08	23.47	25.63	24.55	32.41	33.28	32.84
T7	21.25	22.35	21.80	27.35	28.32	27.83	34.25	35.63	34.94
T8	19.85	21.25	20.55	25.32	25.65	25.43	33.65	35.20	34.42
T9	17.54	18.67	18.10	22.31	23.77	23.04	30.74	31.05	30.89
T10	16.32	17.65	16.98	24.69	25.63	25.17	30.23	30.29	30.26
S.Em.±	0.34	0.21		0.38	0.17		0.37	0.27	
C. D. at 5% of level	0.96	0.61		0.98	0.48		1.08	0.77	

Table 5: Impact of INM on Stem Diameter at various successive stages of growth

Treatments	Stem Diameter (cm) at various successive stages of growth								
	30 DAT			60 DAT			90 DAT		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T1	0.55	0.47	0.51	0.85	0.91	0.88	1.35	1.41	1.38
T2	0.67	0.88	0.77	1.11	1.25	1.18	1.58	1.62	1.60
T3	0.93	0.96	0.94	1.23	1.31	1.27	2.25	2.33	2.29
T4	1.13	1.15	1.14	1.32	1.38	1.35	2.37	2.48	2.42
T5	1.21	1.28	1.24	1.38	1.46	1.42	2.53	2.64	2.58
T6	1.32	1.39	1.35	1.52	1.50	1.51	2.76	2.81	2.78
T7	1.41	1.45	1.43	1.59	1.61	1.60	3.23	3.41	3.32
T8	1.32	1.44	1.38	1.53	1.55	1.54	3.11	3.25	3.18
T9	1.18	1.32	1.25	1.47	1.47	1.47	2.32	2.65	2.48
T10	1.10	1.23	1.16	1.33	1.36	1.34	2.67	2.81	2.74
S.Em.±	0.03	0.02		0.02	0.01		0.04	0.02	
C. D. at 5% of level	0.08	0.07		0.07	0.04		0.11	0.07	

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