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Yatendra Kumar
Department of Horticulture, Kulbhaskar Ashram P.G. College, Prayagraj, Uttar Pradesh, India

Vishwanath
Department of Horticulture, Kulbhaskar Ashram P.G. College, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Yatendra Kumar
Department of Horticulture, Kulbhaskar Ashram P.G. College, Prayagraj, Uttar Pradesh, India

Studies on effect of integrated nutrients management with PGR on growth and yield of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda

Yatendra Kumar and Vishwanath

Abstract
The present investigation was carried out to study the effect of integrated nutrients management with PGR on growth and yield of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda at the Horticulture Research Farm, Department of Horticulture, Kulbhaskar Ashram P.G. College, Prayagraj, U.P. during the year 2016-2017 and 2017-18 and pooled data of both the year of experiments are taken. The experiment was laid out in a randomized block design with three replications comprising 36 treatment combinations with control. The treatments comprised of Azotobacter, PSB and Vermicompost with Cycocel (2- Chloroethyle Triemethyle Ammonium Chloride). The results revealed that application of the treatment T_{22} (Azotobacter- 500 ml/ha, PSB- 500 ml/ha and Vermicompost- 2.50 t/ha) recorded maximum growth characters, duration of flowering (67.50 days), diameter of maim stem (2.46 cm), number of compound leaves per plant (208.70) and yield parameters *viz*., number of flowers per plant, fresh weight of flower, fresh weight of flower per plant, fresh weight of flower per plot and flower yield per ha (73.10, 8.42 g, 615.97 g, 9.86 kg and 456.27 q/ha). Whereas application of T_{32} (Azotobacter- 750 ml/ha, PSB- 500 ml/ha and Vermicompost- 5.00 t/ha) produced significantly maximum plant height and primary branches per plant at 90 and 120 DAT (75.23 cm, 17.90 and 20.30 per plant respectively), maximum primary branches per plant at 60 DAT (12.20) and length of compound leaves (8.92 cm) were recorded under T_{35} (Azotobacter- 750 ml/ha, PSB- 1000 ml/ha and Vermicompost- 5.00 t/ha), while the fresh weight of plant (360.30 g) was observed under T_{25} (Azotobacter- 500 ml/ha, PSB- 1000 ml/ha and Vermicompost- 2.50 t/ha).

Keywords: African marigold, Azotobacter, Biofertilizers, PSB, integrated nutrients management, Pusa Narangi Gainda and Vermicompost

Introduction
Marigold is commonly used for loose flowers in India, because of its easy cultivation, adaptability to varying soil and climatic conditions, long duration of flowering and excellent keeping quality. Marigold which occupies a prominent place in ornamental horticulture is most popular and commercial flower in India. Marigold a member of family Compositae (*Asteraceae*). The genus *Tagetes* have 33 species (Rydberg, 1945) [15] in which few are important viz., *Tagetes erecta, T. patula*,*T. tenuifolia, T. luicida*(sweet scented marigold), *T. sarmetosa* (climbing marigold), *T. lacera, T. lemmmoni, T. minuta, T. filifolia* (Irish lace). It is native to central and South America specially Mexico (Kalpan, 1960) [8]. It is also designated as "friendship flowers" in United State of America. It was distributed in different part of world from Mexico during early 16th century (Yadav *et al*., 2014) [19]. In India it was also introduced by Portuguese between 1502-1550 AD.

This flower is extensively used for decoration in various religious and social functions, beautification of garden and for other commercial purposes likes extraction of perfume. Its popularity, wide availability and multifarious uses, in no way is comparable with other flowers.It has a short duration to produce marketable flowers with wide spectrum of attractive colours, shape, size and good keeping quality, hence,attracted the attention of flower growers.It is use as cut-flower for vase decoration and other arrangement besides loose flower for making garlands, decoration of buildings, gates, pandals during social functions, marriage ceremonies, worshipping and for floral rangoli. As garden plants for bedding and pot culture, herbaceous border, hanging baskets and window boxes, marigold is commonly grown in every home garden, parks and gardens throughout the country.

Recently, Marigold is grown commercially for carotenoid pigment. The principle source of pigment in plant is xanthophylls particularly lutein and extracted from petals. The marigold pigment is major source of pigment for poultry industry as a feed additive to intensify the yellow colour of egg and broiler skin of chicken. Dietary carotenoids can present in different species of *Tagetes* can use for different purpose. The oil extracted from the all part of *T. patula* has a pronounced odour and acts as a fly repellent. *T. signeta* contained higher essential oil than other species and of good quality which use in perfume industry. The oil of *T. minuta* was reported to possess bronchoditary, trancholizing, spasmolytic and anti inflammatory properties, A beautiful yellow dye is also extracted to colour the sheep wool.

The marigold is also used as a cover crop. The plantation of marigold has found beneficial to reduce the population of nematodes specially *Meloidogyne* species. Husain *et al.* (2011) [7] reported the nematicidal activity in marigold plant. The root of *Tagetes spp*. release the chemical alpha-terthienyl one of the most naturally occurring toxic compound. It is very much beneficial for plant and human. The marigold showed anti-bacterial, anti-microbial and larvicidal activity. An flvonoid 'Patulitrin' responsible for the anti-microbial action of marigold.

Materials and Methods

An investigation was carried out at Horticulture Research Farm, Department of Horticulture, Kulbhaskar Ashram P.G. College, Prayagraj (U.P.) during winter season of the year 2016-2017 and 2017-18. The experimental design to be laid out in Randomized Block Design with three replications and 36 treatments, application of a common dose of NPK (120:60:60 kg/ha) as control. Under treatments as biofertilizers four levels of Azotobacter (0,250,500 and750 ml/ha) and three levels of PSB (0, 500 and 1000 ml/ha) was given as seedling treatment. The treatment comprised three levels of Vermicompost (0, 2.50, 5.00 t/ha) will also be supplemented as organic sources of nutrients during field preparation in selected plots. A fixed dose (400ppm) of cycocel (CCC) was given also as foliar feeding at 30 day after transplanting of seedling in each dose of Azotobacter, PSB and Vermicompost.

The treatments detail is as follows, T_0 (Control), T_1 (Vermicompost- 2.50 t/ha), T_2 (Vermicompost- 5.00 t/ha), T_3 (PSB- 500 ml/ha), T_4 (PSB- 500 ml/ha + Vermicompost- 2.50 t/ha), T_5 (PSB- 500 ml/ha + Vermicompost- 5.00 t/ha), T_6 (PSB- 1000 ml/ha), T_7 (PSB- 1000 ml/ha + Vermicompost- 2.50 t/ha), T_8 (PSB- 1000 ml/ha + Vermicompost- 5.00 t/ha), T_9 (Azotobacter- 250 ml/ha), T_{10} (Azotobacter- 250 ml/ha + Vermicompost- 2.50 t/ha), T_{11} (Azotobacter- 250 ml/ha + Vermicompost- 5.00 t/ha), T_{12} (Azotobacter- 250 ml/ha +PSB- 500 ml/ha),T_{13} (Azotobacter- 250 ml/ha +PSB- 500 ml/ha +Vermicompost- 2.50 t/ha), T_{14} (Azotobacter- 250 ml/ha +PSB- 500 ml/ha +Vermicompost- 5.00 t/ha), T_{15} (Azotobacter- 250 ml/ha +PSB- 1000 ml/ha), T_{16} (Azotobacter- 250 ml/ha +PSB- 1000 ml/ha + Vermicompost- 2.50 t/ha), T_{17} (Azotobacter- 250 ml/ha +PSB- 1000 ml/ha + Vermicompost- 5.00 t/ha), T_{18} (Azotobacter- 500 ml/ha), T_{19} (Azotobacter- 500 ml/ha + Vermicompost- 2.50 t/ha), T_{20} (Azotobacter- 500 ml/ha + Vermicompost- 5.00 t/ha), T_{21} (Azotobacter- 500 ml/ha +PSB- 500 ml/ha), T_{22} (Azotobacter- 500 ml/ha +PSB- 500 ml/ha + Vermicompost- 2.50 t/ha), T_{23} (Azotobacter- 500 ml/ha +PSB- 500 ml/ha + Vermicompost- 5.00 t/ha), T_{24} (Azotobacter- 500 ml/ha +PSB- 1000 ml/ha), T_{25} (Azotobacter- 500 ml/ha + PSB- 1000 ml/ha + Vermicompost- 2.50 t/ha), T_{26} (Azotobacter- 500 ml/ha +PSB- 1000 ml/ha + Vermicompost- 5.00 t/ha), T_{27} (Azotobacter- 750 ml/ha), T_{28} (Azotobacter- 750 ml/ha + Vermicompost- 2.50 t/ha), T_{29} (Azotobacter- 750 ml/ha + Vermicompost- 5.00 t/ha), T_{30} (Azotobacter- 750 ml/ha +PSB- 500 ml/ha), T_{31} (Azotobacter- 750 ml/ha +PSB- 500 ml/ha + Vermicompost- 2.50 t/ha), T_{32} (Azotobacter- 750 ml/ha +PSB- 500 ml/ha + Vermicompost- 5.00 t/ha), T_{33} (Azotobacter- 750 ml/ha +PSB- 1000 ml/ha), T_{34} (Azotobacter- 750 ml/ha +PSB- 1000 ml/ha + Vermicompost- 5.00 t/ha) and T_{35} (Azotobacter- 750 ml/ha +PSB- 1000 ml/ha + Vermicompost- 5.00 t/ha). Observations on various growth and flowering characters were recorded and obtained results were subjected to statistical analysis for interpretation of data.

Results and Discussion

Growth Character

Plant height (cm)

It is obvious from the data given in Table 1 that the maximum plant height was recorded under T_{32} (75.23 cm) followed by T_0 (74.03 cm), T_{22} (73.98 cm) and T_{34} (73.36).While, minimum plant height was noticed under T_1 (57.92 cm), might be due to synergistic effect of biofertilizers with organic manure, resulting in to better availability of nutrients of plant growth promoting substances like Auxin and gibberellins. Similar findings were reported by Gupta, *et al.* (1999) [6] and Kumar, *et al*. (2009) [10].

Stem diameter (cm)

The diameter of stem was significantly influenced by various treatments. The maximum diameter of stem was observed under T_{22} (2.46 cm). Whereas the minimum stem diameter was recorded under T_0 (1.36 cm) this stem diameter might be due to the high availability of integrated nutrients data given in Table 1. Similar findings reported by Gotmare *et al.* (2007) [4].

Number of compound primary branches at 30 days interval (30, 60, 90 and 120 DAT)

Application of different sources augmented on number of compound primary branches per plant at 30, 60, 90 and 120 DAT given in Table 1. Maximum production of compound primary branch was observed under T_{25} (6.30), T_{35} (12.20), T_{32} (17.90) and T_{32} (20.30) at 30, 60, 90 and 120 DAT respectably. Whereas minimum compound primary branches at 30, 60, 90 and 120 DAT was recorded under T_0; the reason for the maximum compound primary branches might be due to availability of major and minor nutrients which enhance the growth and resulting the increase in primary branches. Similar findings were showed by Acharya and Dashora (2004) and Chandrikapure *et al*. (1999) [2, 3].

Number of compound leaves per plant

The numbers of compound leaves per plant was significantly influenced by different source of nutrient at full bloom stages of growth and presented in Table 1. The maximum numbers of compound leaves per plant were recorded with T_{22} (208.70). The minimum number of compound leaves per plant was recorded with control (158.30). The next treatments T_{32} (206.30), T_{31} (203.00) and T_{35} (202.50) were statistically *at par* with each other. However, the lesser number of leaves had recorded with control (158.30). Similar finding were also reported by Rajaduarai *et al.* (2000), Yadav *et al.* (2004) [17], Syamal *et al.* (2006) [16], Pushkar *et al*. (2008) [12].

Length of compound leaves

The highest length of leaves had been recorded in the treatment T_{35} (8.92 cm) at all the stages of plant growth. The minimum length of leaves was recorded in T_1 (5.93 cm). Similar findings were showed by Chandrikapure *et al*. (1999) [3].

Fresh and Dry weight of plant

Maximum fresh weight of plant (360.30 g) was observed under T_{25} followed by T_{26} (353.90 g) and T_{22} (350.0 g) and maximum dry weight of plant was reported with T_{23} (106.30 g). Whereas, minimum fresh weight of plant recorded under T_{10} (266.90 g) and dry weight was recorded with T_1 (66.50 g). Obtained findings were accordance with Gotmare *et al.* (2007) [4], Pushkar *et al*. (2008) [12].

Days taken to first flowering

The days taken to first flower flowering was significantly affected by biofertilizers and organic manures and data recorded on this presented in Table 1. The plant treated with T_{25} was showed early flowering (46.00 days). The plant received the treatment T_3 need maximum number of days (68.6 days) for first flowering. Similar results have been obtained by Kumar *et al.* (2017) [9], Yadav *et al.* (2018) [18].

Duration of flowering

The findings pertaining on duration of flowering is presented in Table 1 and it is clear that maximum duration of flowering (67.20 days) was noticed inT_{22} followed by T_{32} (66.40 days) and T_{35} (63.80 days) while, control plants produced minimum duration of flowering (46.00 days). Findings were accordance with Kumar *et al.* (2017) [9].

Table 1: Effect of different treatment combinations on growth characters of African marigold

Treatments	Height of Plant (cm)	Diameter of main stem (cm)	Number of compound primary branches at 30 day interval				Number of compound leavesper plant	Length of compound leaves	Fresh weight of plant (g)	Dry weight of plant	Days taken to first flowering	Duration of flowering
			30DAT	60 DAT	90 DAT	120 DAT						
T_0	74.03	1.36	3.50	8.60	11.50	13.55	158.30	6.47	276.20	80.10	66.20	46.00
T_1	57.92	1.36	3.80	10.10	11.80	14.50	182.50	5.93	272.40	66.50	62.40	48.40
T_2	68.17	1.52	4.00	10.00	14.70	16.90	178.10	6.13	280.20	71.70	55.80	51.50
T_3	58.47	1.71	4.90	10.60	12.90	14.90	175.30	6.79	284.10	72.90	68.60	55.10
T_4	65.55	1.45	4.70	9.70	15.80	17.90	186.40	6.21	287.30	77.90	67.20	59.10
T_5	61.12	1.62	5.30	10.50	13.50	16.40	177.60	6.96	277.80	76.10	54.00	61.10
T_6	65.22	1.79	3.80	11.10	15.90	17.70	190.30	6.89	312.50	82.20	59.10	57.30
T_7	69.93	1.87	5.50	11.10	17.10	18.30	190.10	6.64	322.20	88.30	55.10	53.10
T_8	59.45	1.65	5.20	11.50	15.30	17.80	186.35	7.21	329.40	84.70	53.10	60.90
T_9	69.20	1.94	3.30	11.00	14.70	16.20	191.40	6.03	279.70	72.30	60.70	56.00
T_{10}	70.05	1.92	4.30	8.50	13.10	14.40	194.70	6.63	266.90	73.70	52.20	62.30
T_{11}	71.07	1.51	4.60	10.20	14.10	15.70	197.20	7.15	302.10	81.40	64.40	58.40
T_{12}	70.15	1.79	3.90	10.30	15.00	17.20	174.30	7.86	340.10	85.80	50.00	47.80
T_{13}	70.05	2.06	5.00	11.00	15.50	17.70	180.10	6.78	320.60	97.40	50.50	48.00
T_{14}	72.23	2.03	3.40	9.80	15.20	18.10	181.90	7.78	327.50	87.00	52.60	62.20
T_{15}	59.47	1.66	4.70	11.80	15.90	17.20	183.20	7.16	335.70	97.20	49.20	57.70
T_{16}	70.56	1.86	5.10	11.30	15.70	17.70	169.90	7.63	327.00	98.30	49.50	64.60
T_{17}	68.81	1.87	4.90	10.20	15.20	18.40	189.60	7.91	348.40	92.10	53.90	63.10
T_{18}	70.45	1.66	4.70	12.10	16.60	17.90	191.90	7.48	291.80	76.70	58.50	49.90
T_{19}	71.26	1.89	5.90	11.60	15.50	17.50	187.90	7.60	284.40	87.20	51.30	62.40
T_{20}	70.55	1.58	4.20	10.00	16.10	17.80	199.90	7.10	303.00	85.40	64.60	63.70
T_{21}	71.72	1.17	4.50	11.3 0	13.10	15.50	187.30	8.13	332.40	99.30	63.10	50.30
T_{22}	73.98	2.46	5.50	12.20	17.00	19.50	208.70	8.49	350.00	102.90	55.70	67.50
T_{23}	72.81	2.32	4.20	10.50	16.10	19.00	200.70	8.25	325.40	106.30	65.10	61.10
T_{24}	71.97	2.16	5.30	8.90	13.70	15.00	167.10	8.03	346.20	92.10	51.10	47.10
T_{25}	72.09	2.34	6.30	11.30	13.20	15.20	189.30	8.05	360.30	94.80	46.00	54.00
T_{26}	71.74	2.31	5.50	10.00	15.90	17.10	179.40	8.07	353.90	96.40	52.70	55.10
T_{27}	70.31	1.96	4.70	11.10	14.50	17.00	168.10	7.92	285.80	79.80	61.10	48.90
T_{28}	72.67	1.95	5.10	11.50	16.50	18.30	184.60	7.29	308.50	83.60	61.90	58.00
T_{29}	72.13	1.56	3.50	10.00	16.10	18.00	186.50	7.33	299.50	90.20	62.10	55.00
T_{30}	71.93	1.85	3.80	10.70	15.50	17.40	187.60	7.95	343.50	82.60	60.60	61.30
T_{31}	73.02	2.22	3.90	9.50	12.60	14.80	203.00	8.86	315.80	100.20	62.40	63.10
T_{32}	75.23	2.00	4.90	11.80	17.90	20.30	206.30	8.41	316.80	89.50	64.10	66.40
T_{33}	71.65	2.16	3.70	9.70	17.00	18.40	189.60	7.45	336.40	81.90	54.90	54.60
T_{34}	73.36	2.31	4.30	10.50	16.60	17.70	195.80	8.09	328.60	93.20	51.60	62.60
T_{35}	72.10	2.23	5.90	12.20	16.20	18.40	202.50	8.92	345.20	92.20	54.50	63.80
SE(d)	1.16	0.08	0.17	0.27	0.46	0.62	3.65	0.21	5.73	2.22	1.18	1.36
C.D.(P=0.05)	2.28	0.16	0.34	0.53	0.91	1.22	7.19	0.41	11.30	4.37	2.32	2.69

Yield Character

Number of flower per plant

Different sources of bifertilizers and organic manure showed a significant effect on number of flowers per plant. Maximum number of flowers per plant was noticed under the treatment T_{22} (73.10) followed by treatment T_{35} (72.60) and T_{23} (72.50). The minimum number of flowers per plant was recorded under control (52.00). The result observed presented in Table 2.

Fresh weight of flower per plant

Significant differences among the treatments were observed with regard to fresh weight of flower per plant presented in Table 2. The treatment T_{22} recorded highest fresh weight of flower per plant (615.97 g) followed by T_{35} (585.22g) and T_{34} (570.14g). The minimum fresh weight of flower per plant was recorded in T_0 (277.04 g).

Fresh weight of flower per plot

Different treatment exhibited significant effect on keeping yield of marigold. Maximum fresh weight of flowers per plot was observed under T_{22} (9.86 kg). The minimum fresh weight of flower per plot was observed under control (4.43 kg). This finding was in agreement with the findings of Radhika *et al*. (2010) [13] and Gupta *et al*. (2012) [5] in marigold.

Fresh and Dry weight of flower

The fresh weight and dry weight of flower was influenced by various sources of integrated nutrients management the maximum fresh weight of flower was recorded in T_{22} (8.42 g) and dry weight was recorded under T_{26} (2.08 g) given in Table 2. Whereas, minimum fresh weight (5.32 g) and dry weight (0.89 g) of flower was recorded with control.

Flower yield (q/ha)

Treatments of integrated nutrient management with PGR imparted significant effect on flower yield per hectare (Table 2). The flower yield per hectare ranged from 456.27 q/ ha to 205.22 q/ha. The maximum flower yield of 456.27 q/ ha was recorded in T_{22} (Azotobacter- 500 ml/ha, PSB -500 ml/ha and Vermicompost 2.50 t/ha) followed by treatment T_{35} (433.50 q/ha), T_{34} (422.33 q/ha), and T_{31} (415.83 q/ha). Whereas, minimum flower yield was obtained under control (205.22 q/ha). Similar findings were showed by Pushkar and Rathore (2011) [11] and Abdulsada *et al*. (2013) [1].

Table 2: Effect of different treatment combinations on yield characters of African marigold

Treatments	Number of flower per plant	Fresh weight of flower per plant (g.)	Fresh weight of flower per plot (kg)	Fresh weight of flower (g)	Dry weight of flower (g.)	Yield (q/ha.)
T_0	52.00	277.04	4.43	5.32	0.89	205.22
T_1	54.40	319.70	5.11	5.87	0.95	236.81
T_2	53.10	317.35	5.08	5.97	0.94	235.07
T_3	67.10	406.85	6.51	6.05	1.29	301.38
T_4	68.40	436.79	6.99	6.38	1.10	323.54
T_5	61.70	394.28	6.31	6.39	1.28	292.07
T_6	65.10	365.23	5.84	6.07	1.17	270.54
T_7	64.60	409.59	6.55	6.34	1.37	303.39
T_8	65.80	387.29	6.20	5.88	1.06	286.89
T_9	54.80	363.05	5.81	6.62	1.13	268.92
T_{10}	63.00	415.52	6.65	6.59	1.31	308.03
T_{11}	54.20	342.85	5.49	6.32	1.11	253.97
T_{12}	60.10	433.46	6.93	7.21	1.41	321.09
T_{13}	72.50	484.19	7.75	6.65	1.41	358.66
T_{14}	68.00	495.05	7.92	7.28	1.68	366.50
T_{15}	61.50	460.68	7.37	7.48	1.17	341.25
T_{16}	67.10	508.00	8.13	7.57	1.28	376.37
T_{17}	71.60	558.15	8.93	7.79	1.63	413.44
T_{18}	67.80	453.34	7.25	6.68	1.29	335.81
T_{19}	62.20	448.57	7.18	7.21	1.46	332.28
T_{20}	71.70	501.69	8.03	6.99	1.32	371.62
T_{21}	71.60	529.24	8.47	7.39	1.48	392.04
T_{22}	73.10	615.97	9.86	8.42	1.45	456.27
T_{23}	72.50	558.20	8.69	7.70	2.02	413.85
T_{24}	70.30	529.01	8.46	7.52	1.40	391.86
T_{25}	66.70	502.27	8.04	7.53	1.50	372.05
T_{26}	61.30	494.16	7.91	8.06	2.08	366.04
T_{27}	59.30	438.88	7.02	7.40	1.27	325.10
T_{28}	60.80	428.99	6.86	7.05	1.39	317.77
T_{29}	70.50	493.59	7.90	6.76	1.15	365.63
T_{30}	70.60	522.90	8.37	7.40	1.48	387.34
T_{31}	72.20	561.36	8.98	7.77	1.94	415.83
T_{32}	66.20	516.88	8.27	7.81	1.47	382.88
T_{33}	72.00	535.71	8.57	7.44	1.39	396.82
T_{34}	70.20	570.14	9.12	8.12	1.33	422.33
T_{35}	72.60	585.22	9.38	8.06	1.57	433.50
SE(d)	2.01	8.78	0.31	0.24	0.06	8.64
C.D.(P=0.05)	3.95	17.30	0.61	0.47	0.12	17.02

Conclusion

On the basis of above results, it is concluded that the application of different level of Azotobacter, PSB and Vermicompost with Plant growth retardant (Cycocel @ 400 ppm), treatment T_{22} (Azotobacter- 500 ml/ha, PSB- 500 ml/ha and Vermicompost- 2.50 t/ha) realized better than other treatments on growth and flower yield of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda, under agro-climatic condition of Prayagraj (U.P.).

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