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Yield and quality of African marigold as influenced by biofertilizers and nitrogen levels

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Abstract
An experiment to study the response of biofertilizers and nitrogen levels on yield and quality in African marigold was carried out during *kharif* season of the year 2017-18 at Research Farm, Horticulture Section, College of Agriculture, Nagpur. A field experiment comprised of two factors i.e. factor A and factor B. Factor A consist of 3 levels of biofertilizers (N_0 - Control, N_1 - *Azotobacter* and N_2 - *Azospirillum*) and factor B consist of 5 levels of nitrogen (N_0 - Control, N_1 - 50 kg N ha^{-1}, N_2 - 75 kg N ha^{-1}, N_3 - 100 kg N ha^{-1} and N_4 - 125 kg N ha^{-1}) with fifteen treatment combinations replicated thrice in a Factorial Randomized Block Design. The flower yield characters like flower yield plant^{-1}, flower yield plot^{-1} and flower yield ha^{-1} were recorded maximum with an individual application of B_1 (*Azotobacter*) and N_3 (100 kg N ha^{-1}). Significantly maximum flower yield plant^{-1}, flower yield plot^{-1} and flower yield ha^{-1} were observed in the treatment combination of B_1N_3 (*Azotobacter* and 100 kg N ha^{-1}). Whereas, the quality parameters like weight of flower, flower diameter, flower disc diameter and number of petals flower^{-1} were recorded maximum with an individual application of B_1 (*Azotobacter*) and N_3 (100 kg N ha^{-1}). Significantly maximum weight of flower and flower diameter were observed in the treatment combination of B_1N_3 (*Azotobacter* and 100 kg N ha^{-1}). The interaction effect of biofertilizers and nitrogen levels with respect to quality parameters i.e. flower disc diameter and number of petals per flower were found non-significant in the treatment combination of B_1N_3 (*Azotobacter* and 100 kg N ha^{-1}).

Keywords: Biofertilizers, nitrogen, yield, quality, African marigold

1. Introduction
Marigold occupies a prominent place in ornamental horticulture and it is one of the commercially exploited flower crop. Marigold is a native of Central and South America especially Mexico. It belongs to family Asteraceae and genus *Tagetes*.

Marigold flower for special importance during festival days especially Diwali and Dashehara. There is a constant demand for flowers throughout the year for various functions, festivals, marriages and floral decoration. Recently, dried flower petals of marigold are used in poultry feed to improve the colour of egg yolk as well as broiler's skin. Recently, dried flower petals of marigold are used in poultry feed to improve the colour of egg yolk as well as broiler's skin. Marigold has nematicidal property. The root-knot nematode (*Meloidogyne spp.)* can be effectively managed in the field without pesticides. One alternative to use Nematicide as intercrop with other crops to reduce the population of most common nematodes i.e. *M. incognita* and *M. javanica*.

In Vidharbh marigold was grown in an estimated area of about 935.7 hectare with production of 5589.8 MT and productivity of 6.0 MT ha^{-1}. In Nagpur division marigold was grown in an area of 651 ha. and production of 4109 MT and productivity 6.3 MT ha^{-1} (Anon, 2017).

Biofertilizers are microbial inoculants of selective microorganisms help in improving soil fertility by way of accelerating biological nitrogen fixation, decomposition of plant residues, stimulating plant growth and development ultimately. Nitrogen is the most commonly deficient nutrient in the soil and gives considerable response to this crop. It has the quickest and the most pronounced effect on plant growth and development and ultimately on flower yield. It is an integral part of chlorophyll, which is essential for photosynthesis. Nitrogen is essential constituent of protein and is present in many other compounds of physiological importance in plant metabolism such as nucleotide, phosphatides, alkaloids, enzymes, hormones and vitamines etc.

Materials and Methods

The present investigation was carried out during *kharif* season of the year 2017-18 at Research Farm, Horticulture Section, College of Agriculture, Nagpur to study the effect of biofertilizers and nitrogen levels on growth and flowering in African marigold. A field experiment comprised of two factors i.e. factor A and factor B. Factor A consist of 3 levels of biofertilizers (N_0-Control, N_1 - *Azotobacter* and N_2 - *Azospirillum*) and factor B consist of 5 levels of nitrogen (N_0 - Control, N_1 - 50 kg N ha^{-1}, N_2 - 75 kg N ha^{-1}, N_3 - 100 kg N ha^{-1} and N_4 - 125 kg N ha^{-1}) with fifteen treatment combinations replicated thrice in a Factorial Randomized Block Design. The seeds of African marigold var. African Double Orange were obtained from Horticulture Section, College of Agriculture, Nagpur. The seeds were sown 30 days before the actual transplanting date on previously sterilized raised bed and seedlings were prepared. The beds were prepared thoroughly by mixing soil with farm yard manure and linden powder. Seeds were treated with fungicide for healthy growth of seedlings and sown in lines at 10 cm spacing and 2-3 cm deep in the soil. Seeds were then gently covered with the soil. Seeds were sown on nursery bed of 3 m x 1 m x 0.15 m size. Thirty days old uniform well developed and healthy seedlings of African marigold were selected for transplanting. Seedlings were transplanted on raised bed planting of one seedling $hill^{-1}$ in the experimental field on 13thJuly, 2017at the distance of 45 cm x 30 cm.

Treatment wise biofertilizers were applied at the rate of 5 kg *Azotobacter* and 5 kg *Azospirillum*ha^{-1} in the soil respectively. The *Azotobacter* and *Azospirillum* slurry was prepared by mixing *Azotobacter* and *Azospirillum* culture @ 1 kg ha^{-1} in 5 liters of water. Roots of seedlings were dipped in the slurry for 30 minutes before transplanting in the field. Treatment wise nitrogen levels 50 kg, 75 kg, 100 kg, 125 kg N were calculated according to plot size and subsequently applied in the form of urea. A constant recommended dose of P_2O_5 and K_2O were applied through single superphosphate and muriate of potash according to the plot size. Full dose of P_2O_5 and K_2O along with half dose of N was applied at the time of transplanting. Remaining dose of N was given 30 days after transplanting as per the treatments.

Observations on yield parameters *viz.*, flower yield $plant^{-1}$, flower yield $plot^{-1}$ and flower yield ha^{-1}, on quality parameters *viz.*, weight of flower, flower diameter, flower disc diameter and number of petals $flower^{-1}$. Collected data was statistacially analyzed as per the method given by Panse and Sukhatme (1967) [6]. The appropriate standard error of mean SE (m±) and the critical difference (CD) were calculated at 5% level of probability.

Results and Discussion

Effect of biofertilizers

The data presented in table 1 revealed that, biofertilizers and nitrogen levels had significant effect on yield and quality parameters in African marigold studied in this experiment. However, interaction effect of biofertilizers and nitrogen levels was found to be significant in respect of all the yield and quality parameters except flower disc diameter and number of petals $flower^{-1}$ (Table 2).

Yield Parameters

Significantly, maximum flower yield $plant^{-1}$ (288.22 g), flower yield $plot^{-1}$ (10.37 kg) and flower yield ha^{-1} (134.45 q) was recorded with an application of B_1 (*Azotobacter*). However, minimum flower yield $plant^{-1}$ (221.95 g), flower yield $plot^{-1}$ (7.99 kg) and flower yield ha^{-1} (103.52 q) was recorded in the treatment B_0 (Control).

This might be due to the secretion of growth promoting substances espically cytokinins by the application of *Azotobacter* which increased plant growth as well as flowering as cytokinin helps in branching and development of side buds which resulted increased in flower yield $plant^{-1}$, flower yield $plot^{-1}$ and flower yield ha^{-1}. These results are in close confirmity with the findings of Singh A. K. (2006) [9], who reported that, the application of *Azotobacter* resulted in production of maximum yield of flowers/m^2 in Rose.

Quality Parameters

An application of B_1 (*Azotobacter*) received significantly maximum weight of flower (15.23 g), flower diameter (7.07 cm), flower disc diameter (0.61 cm) which was at par with B_2 (0.60 cm) i.e. application of *Azospirillum* and maximum number of petals $flower^{-1}$ (271.67) which was at par with B_2 (249.99) i.e. application of *Azospirillum*. However, minimum weight flower (9.90 g), flower diameter (4.86 cm), flower disc diameter (0.54 cm) and number of petals per flower (199.97) was recorded in treatment B_0 (Control).

This might be due to better plant growth which indirectly influenced on weight of flower, flower diameter, flower disc diameter and number of petals $flower^{-1}$ apart from nitrogen fixation, *Azotobacter* significantly enhanced uptake of Fe, Zn, Cu and Mo. These findings are in close conformity with the results of Singh A. K. (2006) [9], who reported that the maximum weight of flower, flower diameter, flower disc diameter and number of petals $flower^{-1}$ were obtained with the application of *Azotobacter* in Rose.

Effect of nitrogen

Yield Parameters

Significantly, maximum flower yield $plant^{-1}$ (278.75 g) was recorded with an application of N_3 (100 kg N ha^{-1}) which was at par with N_2 and N_4 (271.60 g and 262.46 g), maximum flower yield $plot^{-1}$ (10.03 kg) which was at par with N_2 (9.77 kg) and maximum flower yield ha^{-1} (130.06 q) which was at par with N_2 and N_4 (126.69 q and 122.45 q). However, minimum flower yield $plant^{-1}$ (220.87 g), flower yield $plot^{-1}$ (7.95 kg) and flower yield ha^{-1} (103.01 q) was recorded in treatment N_0 (0 kg N ha^{-1}).

This might be due to that, nitrogen is an important constituent of nucleotides, phosphatides, enzymes, hormones etc. which have great importance in plant metabolism, augmented crucial role in enhancement of plant growth and resulted in higher flower yield. However, Dhaked *et al*. (2013) [3] noticed that, maximum flower yield/plant and flower yield/ha were obtained under higher dose of nitrogen (100 kg N/ha) in Calendula.

Quality Parameters

An application of N_3 (100 kg N ha^{-1}) was recorded significantly maximum weight of flower (14.02 g) which was at par with the treatment N_2 and N_4 (13.96 g and 13.42 g), maximum flower diameter (6.78 cm) which was at par with N_2 and N_4 (6.44 cm and 6.07 cm), maximum number of petals $flower^{-1}$ (260.87) which was at par with N_2 and N_4 (251.03 and 244.21) and maximum flower disc diameter (0.64 cm) which was at par with N_1 (0.61 cm). However, minimum weight of flower (11.19 g), flower diameter (5.47 cm), number of petals $flower^{-1}$ (220.17) and flower disc diameter (0.50 cm) was recorded in the treatment N_0 (Control).

This might be due to the nitrogen which helped in improving the protein synthesis, more metabolic transport, increased photosynthesis and cell multiplication and results in production of flowers having maximum weight, flower diameter, flower disc diameter and number of petals flower^{-1}. These findings are in close conformity with the results of Dhaked *et al*. (2013) [3], who reported that the maximum flower diameter, weight of single flower were obtained under higher dose of nitrogen (100 kg N/ha) However, Singh A. K. (2006) [9] revealed that, 60 kg N/ha produced maximum number of petals flower^{-1} in Rose.

Interaction effect

Yield Parameters

Data presented in the Table 2 revealed that, the interaction effect due to biofertilizers and nitrogen levels on flower yield was found significant.

The maximum flower yield plant^{-1} (320.34 g) was recorded in the treatment combination of B_1N_3 (*Azotobacter* and 100 kg N ha^{-1}) which was at par with treatments B_2N_3, B_1N_2 and B_1N_1 (305.02 g, 299.46 g and 288.88 g) i.e. *Azospirillum* and 100kg N ha^{-1}, *Azotobacter* and 75 kg N ha^{-1} and *Azotobacter* and 50 kg N ha^{-1} respectively. The maximum flower yield plot^{-1} (11.53 kg) was recorded in the treatment combination of B_1N_3 (*Azotobacter* and 100 kg N ha^{-1}) which was at par with treatments B_2N_3 and B_1N_2 (10.98 kg and 10.78 kg) i.e. *Azospirillum* and 100kg N ha^{-1} and *Azotobacter* and 75 kg N ha^{-1} respectively. The maximum flower yield ha^{-1} (149.46 q) was recorded in the treatment combination of B_1N_3 (*Azotobacter* and 100 kg N ha^{-1}) which was at par with the treatments B_2N_3, B_1N_2 and B_1N_1 (142.33 q, 139.74 q and 134.68 q) i.e. *Azospirillum* and 100kg N ha^{-1}, *Azotobacter* and 75 kg N ha^{-1} and *Azotobacter* and 50 kg N ha^{-1} respectively. However, minimum flower yield plant^{-1} (191.62 g), flower yield plot^{-1} (6.89 kg) and flower yield ha^{-1} (89.31 q) was recorded in B_0N_0 (No bio fertlizer and 0 kg N ha^{-1}).

This might be due to the role of nitrogen and *Azotobacter* through atmospheric nitrogen fixation, better root proliferation, uptake of nutrients and water, higher photosynthetic activity and enhanced food accumulation which might have resulted in better plant growth and subsequently higher flower yield. However, Singh and Kumar (2016) [10] noticed that, the plant received treatment of *Azotobacter* + PSB + 50% N + 50% P + 100% K + FYM recorded, highest flower yield plant^{-1}, maximum flower yield plot^{-1} and maximum flower yield ha^{-1} in Marigold.

Quality Parameters

The interaction effect due to the biofertilizers and nitrogen levels on flower disc diameter and number of petals flower^{-1} was found non-significant; however, it was significant in respect of weight of flower and diameter of flower (Table 2).

The maximum weight of flower (16.87 g) and flower diameter (8.47 cm) which was at par with B_2N_3, B_1N_2 and B_1N_1 (7.43 cm, 7.22 cm and 7.10 cm) i.e. *Azosprillum* and 100 kg N ha^{-1}, *Azotobacter* and 75 kg N ha^{-1} and *Azotobacter* and 50 kg N ha^{-1} respectively recorded in the treatment combination of B_1N_3 (*Azotobacter* and 100 kg N ha^{-1}). However, minimum weight of flower (7.22 g) and flower diameter (3.98 cm) was recorded in B_0N_0 (No biofertlizer and 0 kg N ha^{-1}).

This might be due to combined application of *Azotobacter* and nitrogen as *Azotobacter* is a free living bacteria and has specific role in fixing atmospheric N in soil which enhance the soil fertility and nitrogen encourages the formation of new cell, cell division and cell elongation. Kumar *et al*. (2009) noticed that, diameter of flower and fresh weight of flower were recorded highest under the treatment PSB + *Azotobacter* + full K + FYM + half N and P in African marigold

Table 1: Effect of biofertilizers and nitrogen levels on yield and quality in African marigold

Treatments	Flower yield plant^{-1}(g)	Flower yield plot^{-1}(kg)	Flower yield ha^{-1}(q)	Weight of flower (g)	Flower diameter (cm)	Flower disc diameter (cm)	Number of petals flower^{-1}
Factor A -Biofertilizers							
B_0 - No biofertilizer	221.95	7.99	103.52	9.90	4.86	0.54	199.97
B_1 – *Azotobacter*	288.22	10.37	134.45	15.23	7.07	0.61	271.67
B_2 – *Azospirillum*	263.07	9.47	122.73	13.19	6.22	0.60	249.99
S.E (m) ±	4.54	0.13	6.27	0.47	0.20	0.01	7.86
CD at 5 %	13.17	0.38	18.17	1.37	0.57	0.04	22.79
Factor B - Nitrogen							
N_0 - 0 nitrogen	220.87	7.95	103.01	11.19	5.47	0.50	220.17
N_1- 50 kg ha^{-1}	255.06	9.18	118.95	11.27	5.48	0.61	226.43
N_2- 75 kg ha^{-1}	271.60	9.77	126.69	13.96	6.44	0.58	251.03
N_3- 100 kg ha^{-1}	278.75	10.03	130.06	14.02	6.78	0.64	260.87
N_4- 125 kg ha^{-1}	262.46	9.45	122.45	13.42	6.07	0.57	244.21
S.E (m) ±	5.87	0.17	2.95	0.61	0.25	0.01	10.15
CD at 5 %	17.00	0.49	8.56	1.78	0.74	0.05	29.42
Interaction effect (A x B)							
S.E (m) ±	12.45	0.36	6.27	1.30	0.54	0.03	21.54
CD at 5 %	36.07	1.04	18.17	3.77	1.58	-	-

Table 2: Interaction effect of biofertilizers and nitrogen levels on yield and quality in African marigold

Treatment combinations	Flower yield plant^{-1} (g)	Flower yield plot^{-1}(g)	Flower yield ha^{-1}(g)	Weight of flower (g)	Flower diameter (cm)
B_0N_0	191.62	6.89	89.31	7.22	3.98
B_0N_1	220.66	7.94	102.92	10.09	5.07
B_0N_2	235.73	8.48	109.92	11.23	5.33
B_0N_3	210.89	7.59	98.38	9.35	4.45
B_0N_4	250.85	9.03	117.05	11.61	5.47
B_1N_0	270.89	9.75	126.38	14.33	6.33
B_1N_1	288.88	10.39	134.68	15.30	7.10
B_1N_2	299.46	10.78	139.74	15.52	7.22
B_1N_3	320.34	11.53	149.46	16.87	8.47
B_1N_4	261.52	9.41	121.98	14.10	6.21
B_2N_0	200.09	7.20	93.33	12.02	6.10
B_2N_1	255.63	9.20	119.25	8.41	4.26
B_2N_2	279.61	10.06	130.40	15.12	6.76
B_2N_3	305.02	10.98	142.33	15.85	7.43
B_2N_4	275.02	9.90	128.33	14.56	6.54
S.E (m) ±	12.45	0.36	6.27	1.30	0.54
CD at 5 %	36.07	1.04	18.17	3.77	1.58

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