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Original Research Article

Effect of Biofertilizers and Nitrogen Levels on Growth and Flowering in African Marigold

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A B S T R A C T

An experiment to study the effect of biofertilizers and nitrogen levels on growth and flowering 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 maximum vegetative growth *viz*. plant height, stem diameter, number of branches $plant^{-1}$, plant spread and leaf area were found with the individual application of B_1 (*Azotobacter*) and N_3 (100 kg N ha^{-1}).Significantly maximum stem diameter, number of branches $plant^{-1}$, plant spread and leaf area were observed in the treatment combination of B_1N_3 (*Azotobacter* and 100 kg N ha^{-1}). Whereas flowering parameters in terms of days to first flower bud initiation from transplanting, days to 50 per cent flowering from transplanting and days to first harvesting from transplanting were found earlier with an individual application of B_1 (*Azotobacter*) and N_0 (0 kg N ha^{-1}).Whereas, delay in flowering parameters were recorded in B_0 (Control) and N_4 (125 kg N ha^{-1}). Whereas, significantly minimum days to fully opened flower from bud emergence was found with an individual application of B_1 (*Azotobacter*) and N_3 (100 kg N ha^{-1}). However, significantly maximum flowering span was found with an individual application of B_1 (*Azotobacter*) and N_3 (100 kg N ha^{-1}).

Keywords

Biofertilizers, nitrogen, growth, flowering, African marigold

Introduction

Marigold is one of the commercially exploited flower crop worldwide. It belongs to family Asteraceae and genus *Tagetes*. There are about 33 species of genus *Tagetes*. (Ryderberg, 1915). It is an important raw material for perfume industries. The essential oil from plant and flower can be readily extracted by steam distillation. The oil has pronounced odour and it acts as a repellent to flies. 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. 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 vitamins 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 growth parameters *viz.*, plant height, stem diameter and number of branches $plant^{-1}$were recorded at 75 DAT, plant spread and leaf area were recorded at 50% flowering, on flowering parameters *viz.*, days to first flower bud initiation, days to opening of flower from bud emergence, days to 50 per cent flowering, days to first harvesting and flowering span were recorded in days. Collected data was statistically analyzed as per the method given by Panse and Sukhatme (1967).The appropriate standard error of mean SE (m±) and the critical difference (CD) were calculated at 5% level of probability.

Results and Discussion

The data presented in table 1 revealed that, biofertilizers and nitrogen levels had significant effect on all growth and flowering parameters in African marigold studied in this experiment. However, interaction effect of biofertilizers and nitrogen levels was found to be non significant in respect of all the parameters except number of branches plant^{-1}, plant spread and leaf area (Table 2).

Effect of biofertilizers

Growth Parameters

An application of B_1(*Azotobacter*) treatment was recorded significantly maximum plant height (96.70 cm), stem diameter (1.23 cm), number of branches plant^{-1}(14.61), plant spread(38.86 cm) and leaf area (20.22 cm^2), in respect of plant height it was found statistically at par with B_2(93.26 cm) i.e. application of *Azospirillum*. However, minimum plant height (83.52 cm), stem diameter (0.99 cm), number of branches plant^{-1} (9.90), plant spread (34.67 cm) and leaf area (14.37 cm^2) was recorded in B_0(Control).

This might be due to the fact that, *Azotobacter* gave additive effect in increasing the growth due to secretion of certain growth promoting substances like auxin and gibberellins which resulted in cell elongation and cell multiplication.

These results are in close confirmity with the findings of Pandey *et al.*, (2017), who reported that the most promosing results in respect of plant height, stem diameter, number of branches plant^{-1} and plant spread were obtained from the plants treated with vermicompost @ 2.5 t/ha + *Azotobacter*@ 2 kg/ha + PSB @ 2.0 kg/ha in Dahlia plant. However Singh A. K. (2006) revealed that, the application of *Azotobacter* enhanced the leaf area in Rose plant.

Flowering Parameters

Early flower bud initiation (42.00 days) was recorded in B_1 (*Azotobacter*) treatment. However, delay flower bud initiation (49.17 days) was recorded in the treatment B_0 (Control).Minimum days to fully opened flower from bud emergence (9.66 days) was recorded in B_1 (*Azotobacter*) treatment which was at par with B_2 (10.39 days)i.e. application of *Azospirillum*. However, delay to fully opened flower from bud emergence (11.71 days) was recorded in treatment B_0 (Control).Significantly, minimum days to 50 per cent flowering (62.98 days) was recorded in B_1 (*Azotobacter*) treatment which was at par with B_2 (64.49 days) i.e. application of *Azospirillum*. However, maximum days (67.25 days)to 50 per cent flowering was recorded in the treatment B_0 (Control). Significantly, minimum days to first harvesting from transplanting (49.82 days) was recorded in B_1 (*Azotobacter*) treatment which was at par with B_2 (51.46 days) i.e. application of *Azospirillum*. However, maximum days to harvesting from transplanting (53.88 days)was observed in the treatment B_0 (Control).Significantly maximum flowering span (61.04 days)was recorded in B_1 (*Azotobacter*) treatment which was at par with B_2 (56.52 days) i.e. application of *Azospirillum*. However, minimum flowering span (47.55 days) was recorded in the treatment B_0 (Control).

This might be due to early completion of vegetative primordial to reproductive primordial, probably due to secretion of growth promoting substance like auxins, gibberellins, vitamins and organic acids which promoted faster vegetative growth, early flowering and ultimately maximum flowering span. These findings are in close

conformity with the results of Mahadik *et al.,* (2017), who reported that, minimum days to first flower bud initiation, days to opening of flower, days to 50% flowering were recorded with the application of biofertilizers and 50% RDF (15:100:100 kg ha^{-1} of NPK) + 10 t ha^{-1} VC (50% N through VC) in Chrysanthemum.

However, Bhadoria *et al.,* (2007) revealed that minimum days to first harvesting was recorded with the application of *Azotobacter* culture in Tomato plant and Singh *et al.,* (2015) reported that, treatment of 75 kg N, 75 kg P_2O_5, 75 kg K_2O ha^{-1} + vermicompost 80 q ha^{-1} + *Azotobacter* 3.3 kg ha^{-1} recorded maximum duration of flowering in Marigold.

Effect of nitrogen

Growth Parameters

Significantly maximum plant height (96.51 cm) was recorded with an application of N_3 (100 kg N ha^{-1}).However, minimum plant height (88.33 cm) was found in N_0 (Control).

An application of N_3(100 kg N ha^{-1}) was significantly recorded maximum stem diameter (1.22 cm) which was at par with N_2 (1.17 cm) i.e. 75 kg N ha-1. However, minimum stem diameter (1.03 cm) was recorded in N_0 (Control). Significantly maximum number of branches $plant^{-1}$(14.35) was recorded in N_3 (100 kg N ha^{-1}) which was at par with N_2 (13.49) i.e. 75 kg N ha^{-1}.

However, minimum number of branches (10.80) was recorded in N_0 (Control). Significantly maximum plant spread (38.10 cm) was recorded in N_3 (100 kg N ha^{-1}) which was at par with N_2 and N_4 (38.07 cm and 37.62 cm) i.e. 75 kg N $ha^{-1}$and 125 kg N ha^{-1} respectively. Whereas, minimum plant spread (35.17 cm) was recorded in N_0 (Control).Significantly maximum leaf area (20.37 cm^2) was recorded in N_3 (100 kg N ha^{-1}). Whereas, minimum leaf area (15.64 cm^2) was recorded in N_0 (Control).

The increase in growth parameters might be due to the fact that, nitrogen is a constituent of protein which is responsible for the formation of protoplasm, thus affecting cell division and cell enlargement and ultimately better vegetative growth. Being a constituent of protoplasm, nitrogen is involved in the basic reaction of photosynthesis providing its role in total biomass production. These findings are in close conformity with the results of Dhaked *et al.,* (2013), who reported maximum plant height, number of branches/plant, plant spread and stem diameter under higher dose of nitrogen (100 kg N/ha) in Calendula. However, Patel *et al.,* (2010) revealed that, the higher level of nitrogen i.e. 200 kg/ha recorded significantly maximum plant height and leaf area in Golden rod.

Flowering Parameters

Significantly, an early flower bud initiation (41.75 days) was recorded in N_0 (Control) i.e. 0 kg N ha^{-1} which was at par with N_1 and N_2 (44.76 days and 44.40 days) i.e. 50 kg N $ha^{-1}$and 75 kg N ha^{-1} respectively. However, late flower bud initiation (49.47 days) was recorded in the treatment N_4 (125 kg N ha^{-1}). Significantly, minimum days to fully opened flower from bud emergence (9.70 days) was recorded in N_3 (100 kg N ha^{-1}).

However, maximum days to fully opened flower from bud emergence (11.39 days) was observed in the treatment N_0 (Control).

An application of N_0 (0 kg N ha^{-1}) exhibited significantly minimum days to 50per cent flowering (62.31 days), which was at par with N_2, N_1 and N_3 (64.65 days, 64.92 days and 64.94 days) i.e. 75 kg N ha^{-1}, 50 kg N $ha^{-1}$and 100 kg N ha^{-1} respectively.

Table.1 Effect of biofertilizers and nitrogen levels on growth and flowering in African marigold

Treatments	Plant height (cm)	Stem diameter (cm)	Number of branches plant^{-1}	Plant spread at 50% flowering (cm)	Leaf area at 50% flowering (cm^2)	Days to first flower bud initiation	Days to fully opened flower from bud emergence	Days to 50% flowering	Days to first harvesting	Flowering span
Factor A -Biofertilizers										
B_0 - No biofertilizer	83.52	0.99	9.90	34.67	14.37	49.17	11.71	67.25	53.88	47.55
B_1 – *Azotobacter*	96.70	1.23	14.61	38.86	20.22	42.00	9.66	62.98	49.82	61.04
B_2 – *Azospirillum*	93.26	1.13	12.92	37.40	19.04	44.53	10.39	64.49	51.46	56.52
S.E (m) ±	1.32	0.01	0.27	0.48	0.33	1.01	0.30	0.84	0.66	1.72
CD at 5 %	3.83	0.04	0.80	1.40	0.98	2.94	0.88	2.45	1.94	5.00
Factor B - Nitrogen										
N_0 - 0 nitrogen	88.33	1.03	10.80	35.17	15.64	41.75	11.39	62.31	49.51	50.39
N_1- 50 kg ha^{-1}	89.08	1.04	11.38	35.93	16.05	44.76	11.09	64.92	51.10	52.08
N_2- 75 kg ha^{-1}	91.27	1.17	13.49	38.07	19.06	44.40	10.22	64.65	51.39	57.31
N_3- 100 kg ha^{-1}	96.51	1.22	14.35	38.10	20.37	45.79	9.70	64.94	52.33	59.66
N_4- 125 kg ha^{-1}	90.61	1.12	12.36	37.62	18.29	49.97	10.52	67.71	54.28	55.73
S.E (m) ±	1.71	0.01	0.35	0.62	0.43	1.31	0.39	1.09	0.86	2.23
CD at 5 %	4.95	0.05	1.03	1.81	1.26	3.79	1.14	3.17	2.50	6.46
Interaction effect (A x B)										
S.E (m) ±	3.62	0.05	0.79	1.33	0.92	2.78	0.83	2.32	1.83	4.73
CD at 5 %	-	-	2.20	3.85	2.68	-	-	-	-	-

Table.2 Interaction effect of biofertilizers and nitrogen levels on growth in African marigold

Treatment combinations	Number of branches plant^{-1}	Plant spread at 50% flowering (cm)	Leaf area at 50% flowering (cm^2)
B_0N_0	8.10	30.13	12.87
B_0N_1	10.14	35.12	13.14
B_0N_2	10.66	36.54	12.97
B_0N_3	9.54	34.37	17.74
B_0N_4	11.07	37.16	15.17
B_1N_0	12.78	38.11	19.39
B_1N_1	14.88	38.89	19.47
B_1N_2	15.67	39.10	22.14
B_1N_3	17.30	40.71	22.32
B_1N_4	12.44	37.50	17.82
B_2N_0	11.53	37.25	14.67
B_2N_1	9.11	33.78	15.54
B_2N_2	14.15	38.56	22.07
B_2N_3	16.21	39.22	21.07
B_2N_4	13.57	38.21	21.88
S.E (m) ±	0.76	1.33	0.92
CD at 5 %	2.20	3.85	2.68

However, significantly maximum days (67.71 days) for 50per cent flowering was recorded in N_4 (125 kg N ha^{-1}).Significantly minimum days to first harvesting from transplanting (49.51 days) was recorded in the treatment N_0 (Control) i.e. 0 kg N ha^{-1} which was at par with the treatment N_1 and N_2 (51.10 days and 51.39 days) i.e. application of 50 kg N ha^{-1} and 75 kg N ha^{-1}respectively.

Whereas, an application of N_4 (125kg N ha^{-1}) was recorded maximum days (54.28 days) to first harvesting from transplanting. This delay might be due to higher dose of nitrogen which encouraged vegetative growth of the plants and prolonged the time required by the plant to enter into the reproductive phase from vegetative phase and thereby delayed flowering.

These findings are in close conformity with the results of Tembhare *et al.,* (2016), who reported that the minimum days to first flower bud initiation from date of transplanting, days taken to 50 per cent flowering and days to first harvesting of mature flower was found with the application of N_0 (0 kg N/ha) in China aster.

Significantly maximum flowering span (59.66 days)was recorded with the application of N_3 (100 kg N ha^{-1}) which was at par with N_2 and N_4 (57.31 days and 55.73 days) i.e. 75 kg N $ha^{-1}$and 125 kg N ha^{-1}respectively. Whereas, an application of N_0 (0 kg N ha^{-1}) was recorded minimum flowering span (50.39 days).This might be due to more metabolic transport, increased photosynthesis and cell multiplication.

The similar results were obtained by Kumar *et al.,* (2009) revealed that, increase in flowering span of marigold (41.39 and 45.79 days) with the application of PSB + *Azotobacter* + 50% N and P + full K + FYM over control in Marigold.

Interaction effect

Growth Parameters

The interaction effect, due to biofertilizers and nitrogen levels on plant height and stem diameter was found non significant; however it was significant in respect of number of branches $plant^{-1}$, plant spread and leaf area. The data from table 2 revealed that, African marigold produced the maximum number of branches $plant^{-1}$(17.30) in the treatment combination of B_1N_3 (*Azotobacter* and 100 kg N $ha^{-1)}$ which was at par with B_2N_3 and B_1N_2 (16.21 and 15.67) i.e. *Azospirillum* and 100 kg N $ha^{-1}$and *Azotobacter* and 75 kg N ha^{-1} respectively. However, minimum number of branches $plant^{-1}$ (8.10) was recorded in B_0N_0 (No biofertlizer and 0 kg N ha^{-1}). The maximum plant spread (40.71 cm) was recorded in the treatment combination of B_1N_3 (*Azotobacter* and 100 kg N $ha^{-1)}$ which was at par with B_2N_3, B_1N_2, B_1N_1, B_2N_2, B_2N_4, B_1N_0, B_1N_4, B_2N_0 and B_0N_4, (39.22 cm, 39.10 cm, 38.89 cm, 38.56 cm, 38.12 cm, 38.11 cm, 37.50 cm, 37.25 cm and 38.12 cm respectively). However, minimum plant spread (30.13 cm) was recorded in B_0N_0 (No biofertlizer and 0 kg N ha^{-1}).

The maximum leaf area (22.32 cm^2) was noted in the treatment combination of B_1N_3 (*Azotobacter* and 100 kg N ha^{-1}) which was at par with B_1N_2, B_2N_2, B_2N_4 and B_2N_3(22.14 cm^2, 22.07 cm^2, 21.88 cm^2 and 21.07 cm^2 respectively). However, minimum leaf area (12.87 cm^2) was recorded in B_0N_0 (No biofertlizer and 0 kg N ha^{-1}).

This might be due to the fact that, biofertilizers in combination with nitrogen levels imparted vigour growth, maximum number of branches, plant spread and leaf area. However Singh *et al.,* (2015) noticed that, treatment of 75 kg N, 75 kg P_2O_5, 75 kg K_2O ha^{-1} + vermicompost 80 q ha^{-1} +

Azotobacter 3.3 kg ha^{-1} recorded maximum plant spread, leaf area (49.46 cm^2), and number of branches $plant^{-1}$.

Flowering Parameters

The interaction effect due to the biofertilizers and nitrogen levels on flowering parameters was found non significant.

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