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Effect of different sources of nitrogen on the growth, flowering and yield of African marigold (*Tagetes erecta* L.) cv. summer sugat

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Abstract
A field trial experiment was laid out at Andro Research Farm of Central Agricultural University, Imphal, Manipur during 2016-17. The experiment was laid out in a randomized block design with 11 treatments and replicated thrice. The results generated from the experiment showed that the treatment 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* gave the maximum plant height (85 cm), plant girth (1.28 cm), plant spread (48.25 cm), number of branches per plant (13.89), diameter of flowers (7.93 cm), number of flowers per plant (19.00), fresh weight of a single flower (8.93 g) and duration of flowering (60.67 days) in African marigold which was followed by the application of 50 per cent N (Urea) + 50 per cent N (FYM) + *Azospirillum*. However, the least number of days for the first flower bud emergence (33.67 DAT) was observed in the treatment application of 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum.* The application of 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* gave the maximum yield of flowers per plant (174.51 g/plant), yield of flowers per hectare (11295.94 kg/ha) and dry matter production (29.76 g/plant).

Keywords: African marigold, *Azospirillum*, vermicompost, FYM

1. Introduction
Marigold is one of the most important commercially cultivated crops of the country. Marigold is botanically known as *Tagetes* sp. and it belongs to the family of Compositae. It has chromosome number 2n = 24. *Tagetes erecta* is commonly grown by the farmers on large scale for commercial purpose. It is one of the most important commercial loose flower crop grown in India. The flower is mainly utilized for various religious occasions and it is used for decoration in marriage ceremonies and other social functions. It has its utility in making garlands, potpourri, perfumes and other utilities. Cultivation of marigold is gaining momentum day by day among the farmers as it is easy to grow with its short duration and wide adaptability and lucrative returns.
Nutrients are the key elements for flowering plants for proper growth and development with high quality produce. Most of the growers largely depend upon the chemical fertilizers, pesticides, herbicides etc., and this has adversely affected the soil productivity, soil health and environmental quality. Therefore, it has become imperative that the chemical fertilizers be used judiciously and the nutrient requirement can be amended by the use of other organic and biological fertilizers. (Sharma *et al.*,) [10]. With this background, the present study has been take up to study the best source of nitrogen from nitrogenous fertilizer like urea, Farm Yard Manure, Vermicompost and various combinations of urea with vermicompost, FYM and *Azospirillum*.

2. Materials and methods
The experiment was carried out on marigold variety "Summer Sugat" at the Horticultural Research Farm (HRF), Andro of Central Agricultural University (CAU) during the year 2017 to standardize the different sources of nitrogen on the growth, flowering and yield of African marigold. The place, where the experiment was conducted, is situated at a distance of 32 Km from College of Agriculture, Central Agricultural University, Imphal. It is located at latitude of 24°45.89′ N with longitude measuring 94°03.46′ E at an elevation of 808-940 m above mean sea level. The experiment was laid out in a Randomized Block Design (RBD) with 11 treatments replicated three times. The treatments included 100 per cent RDN (Control) (T_1), 100 per cent N from FYM (T_2), 100 per cent N from vermicompost (T_3),

75 per cent N (Urea) + 25 per cent N (FYM) (T_4), 50 per cent N (Urea) + 50 per cent N (FYM) (T_5), 50 per cent N (Urea) + 50 per cent N (FYM) + *Azospirillum* (T_6), 75 per cent N (Urea) + 25 per cent N (Vermicompost) (T_7), 50 per cent N (Urea) + 50 per cent N (Vermicompost) (T_8), 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* (T_9), 25 per cent N (Urea) + 75 per cent N (FYM) (T_{10}) and 25 per cent N (Urea) + 75 per cent N (Vermicompost) (T_{11}). The recommended dose of nitrogen was 250kg/ha. The soil of the experimental plot was found to be acidic with pH of 5.15 with clay soil type and organic carbon content of 1.59 %. The soil has an available nitrogen, phosphorus and potassium of 428.58 kg/ha (medium), 36.27 kg/ha (medium) and 249.35 kg/ha (medium).The plot size was 3.6 m^2 (4 m X 0.9 m) and 30 plants were planted in each plot. The seedlings were transplanted at a spacing of 40 cm x 30 cm. The data collected for various parameters were subjected to a statistical analysis by Fisher's method of analysis of variance for testing the significance of the treatments effect and their interpretation of data as given by Gomez and Gomez [6].

3. Results and discussion

3.1 Vegetative parameters

The various vegetative parameters were significantly influenced by the different treatments used in the experiment. The data presented in Table 1 indicated that the maximum plant height (85 cm) was recorded in treatment T_9 consisting of 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* which was statistically at par with 50 per cent N (Urea) + 50 per cent N (FYM) + *Azospirillum* (T_6) with the value 76.56 cm and the minimum value for the plant height (62.00 cm) was observed in the treatment of 100 per cent of N from FYM (T_2). The plant girth and plant spread were found to be the highest in the treatment application of 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* (T_9) recording a value of 1.14 cm and 48.25 cm respectively. The plant girth was found to be statistically at par with the treatment application of 50 per cent N (Urea) + 50 per cent N (FYM) + *Azospirillum* (T_6) recording a value of 1.13 cm. The least plant girth (0.81 cm) and plant spread (31.81 cm) were recorded in the treatment application of 100 per cent of N from FYM (T_2).

The increase in the plant vegetative growth in the combined application of chemical fertilizers, organic manures and bio-fertilizers might be attributed to the fact that application of the different sources of nitrogen might have enhanced the cell division, protein synthesis and metabolite transport which might have triggered the vegetative growth of the plants. And the application of bio-fertilizers might have supplemented in fixing the atmospheric nitrogen and thus making it easily available to the plants. The presence of vermicompost might have helped in the production of growth hormones, enzymes and supply macro and micro nutrients. The present findings have been found to be in accordance with those of Sharma *at al.* [9], Kumar *et al.* [7] in marigold and Verma *et al.* [13] in chrysanthemum.

The data pertaining to the number of branches varied significantly due to the different treatments. The statistical data given in Table 1 showed that the highest number of branches per plant (13.89) was observed in the treatment application of 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* (T_9) and this was statistically at par with the treatment application of with 50 per cent N (Urea) + 50 per cent N (FYM) + *Azospirillum* (T_6) recording a value of 12.55. Meanwhile, the minimum number of branches was observed in the treatment consisting of 100 per cent of N through FYM (T_2) (8.78). The beneficial effect of vermicompost by proper decomposition and mineralization of organic manure and of bio-fertilizers might have attributed to the proper translocation of nutrients from the soil and enhanced the supply of micro and macro nutrients. This might have favoured the stimulation and production of auxiliary buds formation resulting in the formation of more number of branches. These findings are in conformity with the findings of Singh *et al.* [11] in marigold and Verma *et al.* [13] in chrysanthemum.

3.2 Flowering parameters

The data presented in Table 2 disclosed that the combined application of chemical, organic and biological sources of nitrogen had some significant influence on the flowering characteristics of the plants. It was observed that the plants treated with 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* (T_9) took the least number of days for the flower buds to emerge with a recorded value of 33.67 DAT and this was found to be statistically at par with the treatment application of with 50 per cent N (Urea) + 50 per cent N (FYM) + *Azospirillum* (T_6) and 100 per cent N from Urea (T_1) (36.00 and 37.33 DAT respectively). The maximum number of days was taken by the treatment of 100 per cent FYM (T_2) and the number of days recorded was 50.33 DAT. This might have been due to the early completion of the early vegetative growth and the fast transition of the vegetative phase to the reproduction phase might have induced early bud initiation. Similar findings have been recorded in Rolaniya *et al.* [8] in marigold, Chaitra, [3] in China aster and Chougala *et al.* [5] in Double daisy.

It is evident from the data shown in Table 2 that the diameter of the flowers differed significantly due to the application of the different treatments. The statistical data revealed that the maximum diameter of flowers were observed in the treatment application of 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* (T_9) recording a value of 7.90 cm. This was observed to be par with the treatment consisting of with 50 per cent N (Urea) + 50 per cent N (FYM) + *Azospirillum* (T_6) recording a value of 7.17 cm. The minimum diameter of flower (4.6 cm) was observed in the treatment consisting of 100 per cent of N from FYM (T_2). The increase in the flower diameter might be attributed to the easy availability of the nutrients which in turn caused greater activity of meristematic tissue and active cell elongation in the flower resulting in the increased flower diameter. The positive effect of vermicompost on the flower diameter has been reported by Barik and Saravanan [2] in Dahlia.

As depicted in Table 2, it was observed that the maximum number of flowers per plant (19.00) was recorded in the plants treated with 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* (T_9). The lowest number of flowers per plant (12.17) was observed in the treatment consisting of 100 per cent of N through FYM (T_2). This increase in number of flowers might be attributed to the integrated approach of the fertilizers, vermicompost and *Azospirillum* which might have resulted in making the nutrients available to the plants easily and better food accumulation in the plants subsequently leading to more number of flowers. These findings have been reported by Sunitha and Hunje [12] in marigold and Verma *et al.* [13] in chrysanthemum.

The statistical data given in Table 2 showed that the application of 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* (T_9) was significantly better than the other treatments used in the experiment in terms of the fresh weight of a single flower (8.93 g) and this treatment was statistically at par with the treatment consisting of with 50 per cent N (Urea) + 50 per cent N (FYM) + *Azospirillum* (T_6) (8.45 g). The application of 100 per cent FYM (T_2) gave the minimum fresh weight of a single flower (5.12 g). The maximum duration of flowering with value of 60.67 days was noticed in the plants receiving the treatment of 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* (T_9). The value of 36.78 days was recorded to be the minimum duration of flowering in African marigold plants receiving the treatment of 100 per cent FYM (T_2). This may be attributed to the better uptake of nutrients especially nitrogen, as nitrogen influence the growth characters which will in turn increase the photo-assimilates diversion to the developing flower buds and thus increased the flower weight These findings were in accordance with the findings of Verma *et al.* [13] in chrysanthemum and Barik and Saravanan [2] in Dahlia.

Table 1: Effect of different sources of nitrogen on the vegetative growth of African marigold.

Treatment	Plant Height (cm)	Plant girth (cm)	Plant spread (cm)	No. of branches per plant
T_1 -100 per cent RDN (Control)	74.11	1.06	40.17	11.00
T_2 - 100 per cent N from FYM	62.00	0.81	31.81	8.78
T_3 -100 per cent N from vermicompost	67.07	0.83	33.03	8.89
T_4 - 75 per cent N (Urea) + 25 per cent N (FYM)	72.22	0.93	37.05	9.67
T_5 - 50 per cent N (Urea) + 50 per cent N (FYM)	71.30	0.90	36.22	10.36
T_6 - 50 per cent N (Urea) + 50 per cent N (FYM) + *Azospirillum*	76.56	1.14	42.11	12.55
T_7 - 75 per cent N (Urea) + 25 per cent N (Vermicompost)	73.44	0.99	38.04	9.89
T_8 - 50 per cent N (Urea) + 50 per cent N (Vermicompost)	71.89	0.94	37.67	9.56
T_9 - 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum*	85.00	1.28	48.25	13.89
T_{10} - 25 per cent N (Urea) + 75 per cent N (FYM)	70.67	0.84	34.55	9.11
T_{11} - 25 per cent N (Urea) + 75 per cent N (Vermicompost)	70.78	0.88	35.22	9.30
S.Ed(±)	5.13	0.10	1.85	1.02
CD(0.05)	10.70	0.20	3.86	2.12

Table 2: Effect of different sources of nitrogen on the flowering behaviour of African marigold.

Treatment	Bud initiation (DAT)	Diameter of flowers (cm)	No. of flowers	Fresh weight of single flower (g)	Duration of flowering (days)
T_1 -100 per cent RDN (Control)	37.33	6.10	15.50	7.69	51.44
T_2 - 100 per cent N from FYM	50.33	4.60	12.17	5.12	36.78
T_3 -100 per cent N from vermicompost	48.00	4.80	13.00	5.40	39.11
T_4 - 75 per cent N (Urea) + 25 per cent N (FYM)	43.33	5.57	14.50	6.32	44.67
T_5 - 50 per cent N (Urea) + 50 per cent N (FYM)	44.00	5.50	13.67	6.12	44.22
T_6 - 50 per cent N (Urea) + 50 per cent N (FYM) + *Azospirillum*	36.00	7.17	16.33	8.45	51.78
T_7 - 75 per cent N (Urea) + 25 per cent N (Vermicompost)	40.67	6.00	15.33	6.89	47.11
T_8 - 50 per cent N (Urea) + 50 per cent N (Vermicompost)	41.67	5.63	15.17	6.56	45.00
T_9 - 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum*	33.67	7.93	19.00	8.93	60.67
T_{10} - 25 per cent N (Urea) + 75 per cent N (FYM)	45.67	5.03	13.67	6.05	42.00
T_{11} - 25 per cent N (Urea) + 75 per cent N (Vermicompost)	45.33	5.17	13.83	6.12	43.22
S.Ed(±)	2.63	0.77	1.16	0.53	2.13
CD(0.05)	5.48	1.61	2.42	1.11	4.44

3.3 Yield parameters

The findings pertaining to the yield of the flowers are given in Table 3. The recorded data showed that the plants applied with 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* (T_9) gave the maximum flower yield per plant (174.51 g). The minimum flower yield per plant (80.10 g) was recorded in the plants applied with 100 per cent N through FYM (T_2).

The data presented in Table 3 indicated that the yield of the flowers per hectare was significantly influenced by the treatments given to the plants. The yield of flowers per hectare (11295.94 kg/ha) was the highest in the plants treated with 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* (T_9) and this treatment was found to be superior to all the other treatments used in the experiment. Meanwhile, the yield of the flowers per hectare (4269.86 kg/ha) was found to be the least in the plants treated with 100 per cent N through FYM (T_2). Increase in the yield of the flowers of marigold may be due to the better growth of the plants such as height, spread and number of branches and higher number of flowers per plants, weight of flowers and flower size and hence, subsequently the yield per hectare was increased. These results are in conformity with that of Verma *et al.* [13], Angadi [1] in chrysanthemum, and Chaudhary *et al.* [4] in gladiolus.

It is evident from the data given in Table 3 that the dry matter production in the African marigold cultivars was significantly influenced by the different treatments. The highest dry matter production per plant (29.76 g) was observed in the plants receiving the application of 50 per cent N (Urea) + 50 per cent

N (Vermicompost) + *Azospirillum* (T_9) and this was found to be statistically at par with the treatment consisting of with 50 per cent N (Urea) + 50 per cent N (FYM) + *Azospirillum* (T_6) recording a value of 27.82 g. The lowest dry matter per plant (18.25 g) was observed in the plants receiving the application of 100 per cent of N through FYM (T_2). The probable reason for the increase in the dry matter production of the plant may be attributed to the luxurious plant growth due to the integrated approach of application of chemical along with organic and bio-fertilizers. Similar findings have been reported in the finding of Kumar *et al.* [7] in marigold and Verma *et al.* [13] in chrysanthemum.

4. Conclusion

From the present investigation, it can be concluded that the application of 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* (T_9) was found to be the best treatment among all the treatments to increase the vegetative growth of African marigold (plant height, plant girth, plant spread, number of branches per plant), flowering parameters (duration of flowering, number of flowers per plant, diameter of flowers and fresh weight of flowers). However, it was observed that minimum number of days for the first flower bud emergence was taken by the application of 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum* (T_9) in African marigold. The same treatment gave the highest flower yield per plant, flower yield per hectare and dry matter production.

Table 3: Effect of different sources of nitrogen on yield of flowers per plant, yield of flowers per hectare and dry weight of plants of African marigold.

Treatment	Weight of flowers/plant (g)	Weight of flowers/ha (kg)	Dry weight of plants (g)
T_1 -100 per cent RDN (Control)	121.97	6529.43	25.68
T_2 - 100 per cent N from FYM	80.10	4269.86	18.25
T_3 -100 per cent N from Vermicompost	83.63	4484.87	18.47
T_4 - 75 per cent N (Urea) + 25 per cent N (FYM)	107.82	6039.44	20.86
T_5 - 50 per cent N (Urea) + 50 per cent N (FYM)	102.06	5404.37	20.11
T_6 - 50 per cent N (Urea) + 50 per cent N (FYM) + *Azospirillum*	139.57	9834.48	27.82
T_7 - 75 per cent N (Urea) + 25 per cent N (Vermicompost)	118.69	6468.29	23.74
T_8 - 50 per cent N (Urea) + 50 per cent N (Vermicompost)	108.20	6387.02	21.07
T_9 - 50 per cent N (Urea) + 50 per cent N (Vermicompost) + *Azospirillum*	174.51	11295.94	29.76
T_{10} - 25 per cent N (Urea) + 75 per cent N (FYM)	92.17	5005.06	18.81
T_{11} - 25 per cent N (Urea) + 75 per cent N (Vermicompost)	93.23	5069.58	19.54
S.Ed(±)	8.84	567.96	1.05
CD(0.05)	18.45	1184.75	2.18

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