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Effect of source of nitrogen on growth and yield of African marigold (*Tagetes erecta* L.)

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Abstract
The experiment was carried out at Biotechnology-cum-Tissue Culture Centre of the Department of Floriculture and Landscaping, CA, OUAT, Bhubaneswar, Odisha, during the year 2017 - 2018. The experiment was laid out in a Randomized Block Design (RBD) with three replications and eleven treatment combinations comprising of inorganic fertilizers and organic manures. Among the treatments, application of 75% N from Urea and 25% N from vermicompost (T_8) resulted in significant differences in vegetative characters, floral characters and yield attributing traits such as plant height, plant spread (N-S & E-W), number of branches (primary and secondary branches), leaf area, stem diameter, days to 50% flowering, days to first flower bud appearance, days to first harvest, shelf-life of flower, flowering duration, number of flower per plant, number of harvests, number of flower per m^2 and weight (yield) of flower per plant. Size of flower (diameter) and individual flower weight did not vary significantly among the treatments in this experiment.

Keywords: marigold, nutrition, organic manures

Introduction
Marigold (*Tagetes* sp.) occupies a predominant position with respect to loose flowers. It is one of the most commonly grown flowers and is used extensively during religious and social functions. It is belongs to the family Asteraceae. There are 33 species under this genus, but two species i.e., *Tagetes erecta* L., the African marigold, and *Tagetes patula* L., the French marigold are commonly cultivated in India out of which African marigold is the dominant one used for loose flower production in India. African marigold is native to Central and South America especially to Mexico from where it spread to different parts of the world during the early 16th century (Kaplan, 1960) [17].

Owing to the multifarious use and demand of marigold, it is cultivated commercially throughout India. The quality and quantity of the flower are greatly influenced by a climatic, geographical and nutritional factor. Proper fertilization is the primary need for growth and development and for good quality of flower production. Among all the fertilizers, nitrogen plays a critical role in the growth of plant and development. But continuous use of the inorganic fertilizer in the crop field not only deteriorates the soil health but also reduces the soil microbial activities, soil organic content and may cause environmental imbalance (Alan *et al*, 2007) [2]. In contrast to inorganic fertilizer, the use of the organic manures/green manures improves soil structure, improves nutrient exchange capacity and maintains soil health and that is why interests have been rising in organic farming (Mitra, 2010) [21]. Complete organic farming is possible only in subsistence farming and is not possible in commercial floriculture. It is difficult to meet the requirement of nutrients for the crops exclusively through organic manures. In addition, the unavailability of organic manure in such huge quantities is also a constraint. Thus, the necessity to get sustainable flower production calls for an integrated approach to nutrient management. Keeping this in view, the present experiment was conducted to find out optimum combination of organic and inorganic nitrogen for enhanced yield. This practice not only reduces the burden on chemical fertilizers but also balances the use of natural resources coupled with chemical fertilizers to supply micro-nutrients besides maintaining soil fertility.

Materials and Methods
The field experiment was laid out during 2017-2018 at Biotechnology-cum-Tissue Culture Centre of the Department of Floriculture and Landscaping, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha.

For the determination of physical and chemical properties of soil, samples (0-15 cm depth) randomly drawn from different spots of the experimental site before initiation of the experiment and thoroughly mixed to make a representative soil sample. The soil of the experimental field was sandy loam in texture with good drainage facilities with medium fertility status and was medium in available nitrogen and phosphorous and high in available potassium status. Inorganic fertilizer and organic manures are used as a source of nutrients to meet the nutritional requirements of the crops. A popular, high yielding variety of african marigold cv. Bidhan Marigold-2 was chosen for the experiment. This field experiment was laid out in randomized block design with three (3) replications and comprised with eleven (11) treatments i.e. T_1[100% N (FYM)], T_2[100% N (Vermicompost)], T_3[100% N (Mustard oil cake)], T_4[50% N (Urea) + 50% N (FYM)], T_5[50% N (Urea) + 50% N (Vermicompost)], T_6[50% N (Urea) + 50% N (Mustard oil cake)], T_7[75% N (Urea) + 25% N (FYM)], T_8[75% N (Urea) + 25% N (Vermicompost)], T_9[75% N (Urea) + 25% N (Mustard oil cake)], T_{10}[100% N (Urea)] and T_{11}[Control].

The entire site was ploughed thoroughly by cross-ploughing and cross-harrowing and was brought to a fine tilth and the field was exposed to the sun for a period of 4 weeks for soil solarization. After executing the plan of layout, calculated quantities of manures and fertilizers were applied to respective plots as per the treatments and thoroughly mixed in the soil. Well decomposed FYM, vermicompost, mustard oil cake and inorganic fertilizers were applied as basal just one day before transplanting. Well established, 30 days old, uniform, healthy, plants of Bidhan Marigold-2 in poly bags were transplanted at a spacing of 40 cm X 30 cm in experimental plots. First irrigation was given before transplanting and then light irrigation was given immediately after transplanting. This was followed by another two light irrigations on alternate days in initial stages of growth. The crop was irrigated twice a week and irrigation interval was extended up to 5 to 7 days in the later stage depending upon soil moisture and the climatic conditions. As and when required, spraying of insecticides and fungicides was done to protect the crop from pests and diseases. Bavistin @ 2% was sprayed as a prophylactic measure to control blight and leaf spot. Spraying of fungicide like sulfex @ 2g/ lit. and pesticide like imidaclorprid @ 0.25ml/lit. was done at 15 days interval from transplanting. Fully-opened flowers were plucked in the morning hours by hand. Field was irrigated in the previous evening to maintain turgidity of flowers and better post-harvest life. After harvesting, flowers were kept in shade with proper ventilation.

Result and Discussion

Vegetative characters

It is revealed from the data presented in table 1 that the application of different inorganic and organic fertilisers in different combinations, significantly influenced different growth parameters of African marigold. The treatment T_8 [75% N (Urea) + 25% N (Vermicompost)] exhibited maximum vegetative growth characters like plant height (64.94 cm), plant spread (N-S) (50.88 cm) and (E-W) (54.42 cm), number of branches per plant [primary branches (1.28) and secondary branches (2.73)], leaf area (8.69 cm^2) and stem diameter (1.37 cm). This might be due to the nutrients flow into the plants and thereby favouring the plant growth and stimulation of auxiliary buds resulting in more plant height. These results are in parallel with those reported by Sunitha *et al.,* (2007) [36] and Gaur *et al.,* (2008) [10] in marigold. The proper dose of inorganic fertilizers is important for the vigorous growth of plants. Vermicompost also enhanced the microflora and enzymatic activity which might have augmented the plant spread. This is in conformity to the findings of Rathi *et al.,* (2005) [30] and Suthar (2005) [37] in marigold. The more nutrient availability resulted in better root and shoot growth and ultimately resulted in a proliferation of more number of branches per plant. Similar findings were also reported by Sunitha *et al.,* (2007) [36] in marigold. The application of vermicompost to the soil, which significantly increased soil enzyme activities such as urease, phosphomonoesterase, phosphodiesterase and any sulphatase as reported by Albiach *et al.,* (2002) and also, stimulated plant growth promoting bacteria (PCB) reported by Gupta *et al.*, (1991). Vermicompost might have helped to make the availability of plant nutrients effectively to crop plant for promoting plant height and plant spread as reported by Chanani *et al.*, (2008) [7]. It is also said that vermicompost act as miracle growth promoter and protector reported by Shasidhara *et al.,* (2002) [32]. Vermicompost helps in increasing the photosynthetic efficiency of the marigold plant, as a result, the leaf area increased. An increase in stem diameter might be due to nitrogen, which is an essential part of nucleic acid which plays a vital role in promoting the plant growth. This confirms the finding of Mandloi *et al.*, (2008) [20] and Singh & Singh (2003) [31, 34]. It is obvious that phosphorus is a constituent of chlorophyll and is involved in many physiological processes including cell division, development of meristematic tissue, photosynthesis, metabolism of carbohydrates, fats and proteins etc. Among the organic manures, vermicompost significantly enhanced the growth of the plants as compared to other manures and fertilisers. Similar results have also been reported by Prakash *et al.*, (2002) [29], Mohd. Rafi *et al.,* (2002) [22], Barman *et al.,* (2003) [5] and Acharya & Dashara (2004) [1].

Table 1: Vegetative characters of marigold as influenced by various treatments.

Treatments		Plant height (cm.)*	Plant spread		Number of branches		Leaf area (cm^2)*	Stem diameter (cm.)*
			North-South (N - S) (cm.)*	East-West (E - W) (cm.)*	Primary branches (numbers)*	secondary branches (numbers)*		
T_1	100% N (FYM)	58.67	46.24	46.13	0.99	2.00	7.23	1.12
T_2	100% N (Vermicompost)	59.91	46.96	47.87	1.06	2.36	7.48	1.22
T_3	100% N (Mustard oil cake)	59.54	46.57	46.14	1.00	2.19	7.46	1.18
T_4	50% N (urea) + 50% N (FYM)	60.20	47.77	47.90	1.07	2.53	7.66	1.25
T_5	50% N (Urea) + 50% N (Vermicompost)	62.41	48.55	49.61	1.20	2.60	7.93	1.28
T_6	50% N (Urea) + 50% N (Mustard oil cake)	61.36	48.34	48.83	1.13	2.60	7.91	1.28
T_7	75% N (Urea) + 25% N (FYM)	64.56	49.56	49.91	1.26	2.69	8.10	1.31
T_8	75% N (Urea) + 25% N (Vermicompost)	64.94	50.88	54.42	1.28	2.73	8.69	1.37
T_9	75% N (Urea) + 25% N (Mustard oil cake)	64.82	50.37	50.57	1.27	2.70	8.20	1.32
T_{10}	100% N (Urea)	64.01	49.27	49.65	1.24	2.60	8.02	1.29

T_{11}	Control	57.33	45.43	45.85	0.96	1.93	6.83	0.89
SE(m) ±		2.11	1.32	1.77	0.10	0.25	0.17	0.10
CD (5%)		4.41	2.75	3.71	0.21	0.53	0.35	0.22

* Significant at 5%

Floral characters

An appraisal of data presented in Table 2 indicate that among all the treatments, days to 50% flowering (40.96 days), days to first flower bud appearance (16.46 days), days to first harvest (28.53 days) was noted significantly the earliest and maximum shelf life of flower (8.34 days) under the treatment T_8 [75% N (Urea) + 25% N (Vermicompost)] as compared to control. This is due to quick cessation of vegetative growth and forcing of the plants to flower earlier as stated by Sreekanth *et al.,* (2008) [35]. The application of higher levels of nitrogen enhanced vegetative growth and delayed both bud initiation and the subsequent 50 per cent flowering. Moreover, higher content of nitrogen might have accelerated protein synthesis, thus promoting earlier flower primordial development. Thus, results are in confirmation with Acharya and Dashora (2004) [1]. The easy uptake of nutrients and simultaneous transport of growth promoting substances to the auxiliary buds, resulting in breakage of apical dominance and resulted in a better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase. These results are reported by Jadhav *et al.,* (2002) [14] and Sehrawat *et al.,* (2003) [31] in marigold. Days to first harvest i.e. first flowering and the opening of a flower were increased linearly with increasing level of nitrogen uptake by the plant. The favourable effect of vermicompost also caused the earliest flowering which lead to earliest harvesting by enhancing soil fertility and moisture retention capacity of the soil. Similar views have been reported by Jain and Gupta (2004) [15] in marigold. Higher dose of nitrogen keeps the flower soft and succulent in texture and this type of texture of flower resulted in higher and faster respiration and dehydration (Anuradha *et al.*,, 1990) [4]. These findings corroborate results obtained by Suthar (2005) [37] and Patel *et al.,* (2011) [28] in marigold, Nethra *et al.,* (1999) [25], Parmar (2007) [27] in China aster.

Table 2: Floral characters of marigold as influenced by various treatments.

Treatments		Days to 50% flowering (days)*	Days to first flower bud appearance (days)*	Days to first harvest (days)*	Shelf-life (days)*
T_1	100% N (FYM)	55.73	31.00	38.46	4.72
T_2	100% N (Vermicompost)	55.14	29.26	36.66	5.74
T_3	100% N (Mustard oil cake)	55.33	30.06	38.06	5.20
T_4	50% N (urea) + 50% N (FYM)	54.83	27.53	35.60	6.15
T_5	50% N (Urea) + 50% N (Vermicompost)	53.13	25.40	34.73	6.66
T_6	50% N (Urea) + 50% N (Mustard oil cake)	54.26	25.93	35.46	6.22
T_7	75% N (Urea) + 25% N (FYM)	50.60	23.53	34.13	7.39
T_8	75% N (Urea) + 25% N (Vermicompost)	40.96	16.46	28.53	8.34
T_9	75% N (Urea) + 25% N (Mustard oil cake)	47.60	19.33	29.66	7.61
T_{10}	100% N (Urea)	52.60	23.80	34.66	7.21
T_{11}	Control	58.73	31.13	39.86	4.23
SE(m) ±		1.84	2.80	2.80	0.10
CD (5%)		3.84	5.85	5.85	0.21

* Significant at 5%

Yield attributing traits

The data presented in Table 3 reveal that highest flowering duration (74.73 days), number of flower per plant (171.80), number of harvests (14.82), number of flowers per m^2 (1416.10), and weight (yield) of flower per plant (1208.22 gm) in marigold increased significantly by combined application of organic manure and inorganic fertiliser under T_8 [75% N (Urea) + 25% N (Vermicompost)] treatment. The improvement in flowering duration might be because of the fact that the combined application of organic and chemical fertilizer improved the soil health, water retention capacity and availability of microorganism. The beneficial effect of organic sources on growth parameters might be attributed due to the fact that after proper decomposition and mineralization of organic fertilizer such as vermicompost, the micro and macronutrient were made available to plants and also helped in solubilizing the fixed form of nutrient in the soil (Hedge *et al.,* 2007) [12]. Similar results on flowering duration were also obtained by Shashidhara and Gopinath (2002) [32]. nitrogen accelerates protein synthesis, thus promoting earlier floral primordial development. This could also be attributed to a higher C/N ratio and increased plant metabolism. The increased vegetative growth and balance C/N ratio could lead to increased synthesis of carbohydrate which ultimately promoted greater flowering. Similar results were also reported by Natarajan and Vijayakumar (2002) [24], Singh *et al.,* (2002) [33], Sehrawat *et al.,* (2003) [31], Gavhane *et al.,* (2004) [11] in marigold, Hunmili and Paswan (2003) [13] in Gerbera. The rich source of macro and micronutrients present in vermicompost like Fe, Zn, enzymes, growth hormones and beneficial effects of microflora might have played a role in producing more number of flowers, which resulted in increased number of flowers per plant and lead to a maximum number of harvest and more number of flowers per square meter. These findings are in accordance with those of Kapadiya *et al.,* (2008) [16], Naik *et al.,* (2008) [23], Dodake *et al.,* (2007) [9] and Sunitha *et al.,* (2007) [36] in marigold, Kulkarni *et al.,* (1996) [18], Panchal (2006) [26], Chaitra and Patil (2007) [6] in China aster. The balanced application of fertilizers resulted in increased carbohydrate assimilation leading to increased vegetative growth. These carbohydrates, when translocated to reproductive organs, underwent hydrolysis and got converted into the reducing sugars which ultimately helped in increasing flower size. These findings corroborate results obtained by Kapadiya *et al.,* (2008) [16] in marigold, Nethra *et al.,* (1999) [25] and Kumar *et al.,* (2003) [19]

in China aster. phytohormones produced by vermicompost enhances the microbial enzymatic activity in soil, which stimulated root growth and induced changes in root morphology, which in turn enhanced the assimilation of the nutrients. Such boosting effect also might be due to higher accumulation of carbohydrates in flower heads with the supplementation of inorganic fertilizers and increased yield. Similar results were recorded by Gaur *et al.*, (2008) [10] in marigold, Chauhan (2005) [8] in chrysanthemum. The data presented in table 3 revealed that the size of flower (diameter) and individual flower weight did not vary significantly between the treatments of organic manures.

Table 3: Yield attributing traits of marigold as influenced by various treatments.

Treatments		Flowering duration (days)*	Number of flower per plant (numbers)*	Number of harvests (numbers)*	Number of flowers per m^2 (numbers)*	Size of flower (diameter) (cm.)	Weight (yield) of flower per plant (gm.)*	Individual flower weight (gm.)
T_1	100% N (FYM)	63.93	152.13	10.99	1267.98	6.02	979.96	6.24
T_2	100% N (Vermicompost)	67.73	158.93	12.18	1323.91	6.15	991.35	6.37
T_3	100% N (Mustard oil cake)	65.26	156.53	11.99	1276.60	6.12	981.04	6.29
T_4	50% N (urea) + 50% N (FYM)	68.40	159.20	12.77	1337.79	6.20	1020.49	6.43
T_5	50% N (Urea) + 50% N (Vermicompost)	70.40	161.20	13.10	1342.79	6.26	1095.29	6.74
T_6	50% N (Urea) + 50% N (Mustard oil cake)	69.66	160.60	13.00	1339.46	6.26	1077.09	6.71
T_7	75% N (Urea) + 25% N (FYM)	71.33	167.60	14.22	1384.44	6.37	1123.30	6.85
T_8	75% N (Urea) + 25% N (Vermicompost)	74.73	171.80	14.82	1416.10	6.60	1208.22	7.09
T_9	75% N (Urea) + 25% N (Mustard oil cake)	72.13	168.06	14.36	1399.99	6.40	1154.02	6.89
T_{10}	100% N (Urea)	70.86	164.66	13.36	1371.67	6.33	1120.77	6.75
T_{11}	Control	57.47	145.56	10.08	1191.97	6.02	867.27	6.16
SE(m) ±		3.79	5.80	1.18	43.15	NS	75.97	NS
CD (5%)		7.91	12.11	2.46	90.02		158.47	

* Significant at 5%

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