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Effect of nutrient management and gibberellic acid on growth, flowering and nutrients availability in post-harvested soil of Marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda

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Abstract
An experiment was carried out at Horticultural Research Centre (HRC) of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, (UP) during winter season of 2017-2018. Among the treatments applied in the study, maximum plant height, plant spread, number of branches per plant, earliest flower bud initiation, days taken to opening of first flower, duration of flowering, length of flower stalk, diameter of flower and number of flowers per plant were recorded with the application of treatment T_9 (100% R.D of NPK (100 kg N, 75 kg P and 75 kg K) + 25% R.D of Vermicompost (17.85 q/ha) + GA_3 100 ppm and minimum values exhibited by control. The maximum available nitrogen in post-harvested soil (131.30 kg/ha) was recorded under treatment T_4, while maximum availability of phosphorus in post-harvested soil (18.50 kg/ha) and potassium (278.25 kg/ha) was recorded under the treatment T_6 and minimum NPK content was found under the treatment T_{12}.

Keywords: Marigold, *Tagetes erecta* L., nutrient management, NPK, GA_3

Introduction
Marigold is an important commercial flower of India belongs to the family Asteraceae. It was originated from Central and South America, especially Mexico, where it spreads to different parts of the world during the early part of 16th century. It is an annual plant with hardy vigorous and erect stem, which are bushy and branching towards the apex. Marigold leaves are profussed, brilliant green and elegantly divided into dentate lanceolate segments. Flower colour of marigold is varied from lemon yellow to yellow, golden yellow, orange or bronze. The flower buds are conspicuous, well-shaped with longitudinal groves. According to the flower shape, it can be grouped into three categories i.e., carnation flowered, chrysanthemum flowered and peony flowered type (Pizzetti and Cooket, 1975) [18]. Nutrients play an important role in growth and development in marigold crops. Organic and inorganic fertilizers are the most important sources for supplying nutrient to the marigold (Nalwadi, 1982) [12]. Among the nutrients, nitrogen is an important metabolic element for growth and development of plant. It is essentially considered as metabolic activities, transformation of energy, essential for metabolism of protein and other biochemical product such as nucleic acid, chlorophyll and protoplasm. Phosphorus is the essential component of protoplasm and chlorophyll which caused conversion of photosynthesis into phospholipids resulting adequate vegetative growth of plant, while potassium plays an essential roles in enzyme activation, protein synthesis, photosynthesis, stomatal movement and energy transfer in higher plants (Marschner, 2012) [9]. Besides nutrients, Plant growth regulators are compounds that in minor amounts modify the physiological processes of plants and ultimately alter the yield and quality. A number plant growth regulators have been widely used in many flowering plants and their efficacy have been demonstrated for nursery production, foliage plants and many other ornamental plants (Sanap *et al*., 2000) [21]. Among the different plant growth regulators, Gibberellic acid plays a major role in plant growth and development. It has been found to be the best for enhancing vegetative attributes along with flower initiation Kumar *et al*., 2003; Rana *et al*., 2005) [8, 20]. Keeping in view the above mentioned important properties of the nutrient management and gibberellic acid, this experiment was designed to study the influence of various doses of nutrients and GA_3 on growth, regulation of flowering time flower yield and nutrients availability in post-harvested soil of marigold.

Materials and methods

Experimental location and climate

Field experiments were conducted during 2017-18 at Horticulture Research Center, Sardar Vallabhbhai Patel University of Agriculture & Technology, Modipuram, Meerut, U.P. (29^0 40′ north and longitude of 77^0 42′ east and at an altitude of 237 meters above the mean Sea level). The climate of Meerut is sub-tropical and semi-arid type with hot summer and severely cold winters and falls under the Agro-climatic Zone 'Trans-Gangetic Plains'. The winters are severe with a minimum temperature of about 3°C with occasional ground frost. In summer the temperature often goes up to 40-45°C in the month of May and June. The average rainfall is 807 mm and mostly received from south-west monsoon in July to September.

Soil characteristics, layout and treatments

The soil of experimental field was sandy clay loam in texture, neutral in reaction, low in soil organic carbon (0.31-0.38%) available nitrogen (113.40 kg ha^{-1}), medium in available phosphorus (12.6 kg ha^{-1}) and potassium (240.5 kg ha^{-1}). The twelve treatments (T_1 = Control (No fertilizer, no manure and no bioregulators), T_2 = 100% R.D of NPK (100 kg N, 75 kg P and 75 kg K), T_3 = 100% R.D of NPK (100 kg N, 75 kg P and 75 kg K) + R.D of FYM to 25% N (50 q/ha), T_4 = 100% R.D of NPK (100 kg N, 75 kg P and 75 kg K) + R.D of Vermicompost to 25% N (17.85 q/ha), T_5 = 75% R.D of N (75 kg) + 100% R.D of PK (75 kg P, 75 kg K) + R.D of FYM to 25% N (50q/ha), T_6 = 75% R.D of N (75 kg) + 100% R.D of PK (75 kg P, 75 kg K) + R.D of Vermicompost to 25% N (17.85 q/ha), T_7 = 100% R.D of NPK (100 kg N, 75 kg P and 75 kg K) + $GA_3$100 ppm, T_8 = 100% R.D of NPK (100 kg N, 75 kg P and 75 kg K) + R.D of FYM to 25% N (50 q/ha) + GA_3 100 ppm, T_9 = 100% R.D of NPK (100 kg N, 75 kg P and 75 kg K) + R.D of Vermicompost to 25% N (17.85 q/ha) + GA_3 100 ppm, T_{10} = 75% R.D of N (75 kg) + 100% R.D of PK (75 kg P, 75 kg K) + R.D of FYM to 25% N (50 q/ha) + GA_3 100 ppm, T_{11} = 75% R.D of N(75 kg) +100% R.D of PK(75 kg P,75 kg K) +R.D of Vermicompost to 25% N(17.85 q/ha) + $GA_3$100 ppm, T_{12} (No fertilizer, no manure and + GA_3 100 ppm were applied. The crop was harvested in the first week of April. Soil was analyzed at initial stage and after completion of the experiment to monitor the changes in nutrient status of total nitrogen (kg/ ha), available phosphorus (kg/ ha) and potassium (kg/ ha) as per the standard methods (Jackson, 1973) [7]. The experiment was laid out in randomized block design (RBD) with three replications. Before applying the vermicompost and composted farmyard manure were tested in laboratory for their different chemical parameters as per standard methods Table-1. Analysis of variance (ANOVA) test was performed using the MSTAT-C (Gomez and Gomez, 1984) [6] for different plant parameters in different treatments.

Table 1: Chemical properties of FYM and Vermicompost

Soil properties	Vermicompost	FYM
pH	7.86	7.81
Organic carbon	290.00 g/kg	256.00 g/kg
Nitrogen %	1.38	0.70
Phosphorus %	0.80	0.50
Potash %	1.20	0.56
$_{Ext.}$Cu (mg/kg)	0.88	0.72
$_{Ext.}$Zn (mg/kg)	275.00	140.00
$_{Ext.}$Fe (mg/kg)	9.20	5.20
$_{Ext.}$Mn (mg/kg)	12.80	7.00
$_{Exch.}$Na (g/kg)	6.80	5.70
$_{Exch.}$Ca (g/kg)	18.80	11.25
$_{Exch.}$Mg (g/kg)	5.8	2.70

Ext. – Extractable, Exch. - Exchangeable

The Pusa Narangi Gainda variety of marigold was used for the study. The true-to-type seed of variety was obtained from Division of Floriculture and Landscaping, IARI, New Delhi. The seeds were sown in nursery bed during mid September and planted after 25 days at a planting distance of 40x40 cm. The fertilizer and manure were applied treatment wise at the time of transplanting. The full dose of phosphorus, potash and half dose of nitrogen were supplied with manure and rest of nitrogen was given at the time of flower bud formation. The cultural operations like irrigation, hoeing and weeding, plant protection measures were done as required by the crop time to time. The growth and flowering parameter was recorded the period of crop, while available nutrients obtained after harvesting of crop.

Result and Discussion

Effect of nutrient management and gibberellic acid on vegetative parameters

The vegetative growth as affected by the application of different doses of nitrogen, phosphorus, potash, various doses of farm yard manure, vermicompost and foliar application of gibberellic acid are presented in Table 2. The maximum plant height (67.33 cm), plant spread (69.20 cm) and number of branches (39.63) were recorded at 90 days after transplanting under the treatment T_9 - (100% R.D of NPK (100 kg N, 75 kg P and 75 kg K) + 25% R.D of Vermicompost (17.85 q/ha) + GA_3 100 ppm). However, minimum plant height (55.67 cm), plant spread (45.73 cm) and number of branches (22.80) observed under control. The growth parameters increased might be due to the presence of a more readily available form of nitrogen, phosphorus and potassium which are the main constituent of chlorophyll, protein and amino acids and plays an important role in cell division, protein synthesis and metabolite transport that help to build the plant tissues. The consistent supply of N, P and K through RDF with additional doses of vermicompost and FYM may play a vital role in promoting growth and development of plant and thus resulted in higher growth attributes (Sharma and Singh, 2007) [24]. Nethra *et al.* (1999) [13] observed the incensement in plant growth of china ester by using vermicompost with recommended NPK in different proportions.The foliar application of GA_3 increased the growth might be due to cell

elongation and rapid cell stimulation as reported by Singh, (2004) [26]. The similar findings have also been reported by Chandrikapure *et al.*, 1999, Mittal *et al.*, 2010, Patil *et al.*, 2016 and Pal *et al.*, 2018) [4, 10, 16, 14, 15] in marigold.

Table 2: Effect of nutrient management and gibberellic acid on growth parameters of marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda

Treatments	Growth characters		
	Plant height (cm)	Plant spread (cm)	No. of branches per plant
T_1	55.67	45.73	22.80
T_2	61.33	52.47	28.33
T_3	61.53	55.33	33.00
T_4	62.53	56.13	34.53
T_5	62.47	58.20	27.93
T_6	63.80	56.07	27.67
T_7	63.33	48.40	32.53
T_8	64.00	66.80	37.67
T_9	67.33	69.20	39.63
T_{10}	63.33	57.07	34.57
T_{11}	63.13	59.27	36.03
T_{12}	61.93	53.47	33.80
SE(m)±	0.53	1.29	0.81
CD at 5%	1.52	3.72	2.33

Effect of nutrient management and gibberellic acid flowering parameters

The flowering attributes as influenced by the application of different doses of nitrogen, phosphorus, potash, various doses of farm yard manure, vermicompost and foliar application of gibberellic acid are presented in Table 3. The minimum days taken to first flower bud initiation (47.81), opening of first flower (86.84) and maximum duration of flowering (73.13 days) were recorded with T_9 (100% R.D of NPK (100 kg N, 75 kg P and 75 kg K) + 25% R.D of Vermicompost (17.85 q/ha) + GA_3 100 ppm) and maximum days required for bud initiation (59.42), opening of first flower (97.40), duration of flowering (56.93 days) were recorded under control. It might be due to higher content of nitrogen which might have accelerated protein synthesis, thus promoting earlier floral primordial development (Acharya and Dashora, 2004) [1]. The earliness in flowering might be due to the fact that GA_3 application enhanced the translocation of food for development of floral primordial, which led to early flowering. This may be due to increased photosynthesis and respiration along with enhanced fixation by GA_3 that led to flower bud initiation (Sen and Sen, 1968) [22]. It is the effect of GA_3 that causes flower initiation and early flowering by decreasing the concentration of ABA in plant shoot (Phengphachanh *et al*., 2012) [17]. The data also revealed that the treatment recieving T_9 (100% R.D of NPK (100 kg N, 75 kg P and 75 kg K) + 25% R.D of Vermicompost (17.85 q/ha) + GA_3 100 ppm produced maximum length of flower stalk (11.27 cm), diameter of flower (7.23 cm) and number of flowers per plant (43.90) whereas, minimum length of flower stalk (7.70 cm), diameter of flower (5.40 cm) and number of flowers per plant (22.87), were recorded under control respectively. The increase in number of flowers by foliar application of GA_3 might be due to increase in number of leaves as well as leaf area as compared to control, which might have enhanced the production and accumulation of increased photosynthates that were diverted to the sink and produced more flowers (Sharifuzzaman *et al*., 2011) [23]. The incensement in flowering parameters might be due to the application of GA_3 increased cell division, cell enlargement, promotion of protein synthesis coupled with higher dry matter of apical dominance (Dalal *et al*., 2009) [5]. These findings close conformity with Thumar *et al*., (2013) [28], Sharma *et al*., (2017) [25] and Patel *et al.,* (2018) [15] in African marigold.

Table 3: Effect of nutrient management and gibberellic acid on flowering parameters of Marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda

Treatments	Days taken to first bud initiation	Days taken to opening of first flower	Duration of flowering (days)	Length of flower stalk (cm)	Diameter of flower (cm)	No. of flowers per plant
T_1	59.42	97.40	56.93	7.70	5.40	22.87
T_2	57.21	93.47	62.73	8.93	5.91	27.61
T_3	55.05	93.40	65.00	9.47	6.11	34.64
T_4	54.51	93.51	65.93	9.60	6.27	37.77
T_5	58.85	96.53	61.67	8.03	6.10	31.59
T_6	58.75	96.80	62.82	8.70	5.78	29.97
T_7	57.48	92.91	61.60	9.60	5.98	33.11
T_8	49.49	88.24	72.47	10.47	6.89	39.88
T_9	47.81	86.84	73.13	11.27	7.23	43.90
T_{10}	52.39	90.40	68.13	10.33	6.86	38.36
T_{11}	52.17	90.30	69.60	10.53	6.69	39.06
T_{12}	55.18	93.93	61.13	8.97	6.00	31.56
SE(m)±	1.10	1.00	0.89	0.22	0.11	0.83
CD at 5%	3.17	2.87	2.54	0.64	0.30	2.38

Effect of nutrient management and gibberellic acid on avilable nitrogen, phosphorous and potassium in post-harvested soil (kg/ha)

The availability of NPK in harvested soil of the crop as influenced by a combination of inorganic fertilizers, FYM, vermicompost and gibberellic acid are presented in Table 4. The maximum available nitrogen (131.30 kg/ha) was recorded under treatment T_4 (100% R.D of NPK (100 kg N, 75 kg P and 75 kg K) + 25% R.D of Vermicompost (17.85 q/ha), while maximum available phosphorus (18.50 kg/ha) and potassium (278.25 kg/ha) was recorded in the treatment T_6 (75% R.D of N (75 kg) + 100% R.D of PK (75 kg P, 75 kg K) + 25% R.D of Vermicompost (17.85 q/ha). The maximum availability of NPK nutrients in harvested soil might be due to the addition of chemical fertilizers and organic manures. Addition to this, the carbon dioxide and organic acids released during the process of decomposition which increased the availability of nutrients from native as well as applied fertilizers. These all might have contributed towards the increased available status of soil with respect to these nutrients (Subbarao, 1982) [27]. The probable reason for higher values of NPK on the application of treatments may be due to additional supply of nutrients in the soil by vermicompost and FYM and lower availability of nutrients in treatment T_{12} might be due to that the foliar application of GA_3 increased the plant growth hence increased the absorption of nutrients. Present findings are closely corroborated by Raju and Haripriya, (2001) [19] in chrysanthemum, Barman *et al*., (2003) [2] in tuberose, Muthamizhselvi *et al*., (2006 [11] in chrysanthemum, Chaitra and Patil (2007) [3] in china aster.

Table 4: Effect of nutrient management and gibberellic acid on available NPK in post-harvested soil of Marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda.

Treatments	Nutrient Status (kg/ha)		
	N	P	K
T_1	102.27	12.13	225.27
T_2	112.50	14.01	248.45
T_3	126.27	15.60	256.20
T_4	131.30	16.27	260.42
T_5	127.63	17.44	272.47
T_6	129.60	18.50	278.25
T_7	108.47	13.28	241.38
T_8	124.25	14.43	244.10
T_9	128.57	15.83	251.98
T_{10}	125.18	16.70	265.10
T_{11}	127.55	17.32	272.23
T_{12}	100.58	11.88	220.42
SE(m)±	0.15	0.14	0.16
CD at 5%	0.42	0.41	0.47

Conclusion

Based on the results obtained from the present study, it may be concluded that, among all the treatments are applied (100% R.D of NPK (100 kg N, 75 kg P and 75 kg K) + 25% R.D of Vermicompost 17.85 q/ha + GA_3 100 ppm) was found to be most effective in improving the growth and flowering of marigold cv. Pusa Narangi Gainda under the agro climatic condition of western Uttar Pradesh. The post-harvested soil obtained from the treatment T_4 exhibited maximum available nitrogen and treatment T_6 had maximum available phosphorus and potassium in the post-harvested soil.

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