Soil and plant response to NPK variations in flower crops: A critical review

Gargi Sharma and ML Verma

Abstract
The flowers are commercially used as cut flowers for interior decorations as well as for flower arrangement and religious offerings. Importance of flowers is not restricted up to the beautification, decoration or preparation of gajara, garland, veni or bouquets but also have the industrial importance too. Thus taking into consideration the different uses of flowers, the demand for floricultural plants is increasing day by day and to meet out the same, a sound and scientific technology, needs to be generated in the form of better fertilization management practices, to be passed on to farming community. In flower crops, growth, yield and nutrient content is significantly affected by application of major nutrients i.e. nitrogen, phosphorus and potassium. From the reviews it is clear that the positive effect of NPK application on the growth and yield attributes of the flower crops is well established.

Keywords: Marigold, growth, nutrients, yield

Introduction
Nutrition plays an important role in the improvement of growth, flowering and yield in marigold. Nutrients directly affect the vegetative growth and yield of crop. Among nutrients nitrogen, phosphorus and potassium are of much importance and to fulfill the requirement of plants they are supplied from outside in the form of fertilizers.
Nitrogen is absorbed by the plants in huge amount and is the most limiting factor for crop production. It is an essential element required by the plants for growth and development. Nitrogen is the chief constituent of several important elements like protein, nucleic acid and amino acids occurring in the plants. An adequate supply of nitrogen is associated with higher photosynthetic activity, vigorous vegetative growth, dark green color of leaves and carbohydrate utilization. Phosphorus is required to promote flowering. Phosphorus is the essential component of protoplasm and chlorophyll material which causes conversion of photosynthates into phospholipids, resulting adequate vegetative growth. It is indispensable constituent of nucleic acid, phospholipids and several enzymes. A good supply of phosphorus is associated with increased root growth and early maturity of crop besides disease resistance in plants. Potassium is also one of the most important nutrients that effect plant growth and development. Potassium activates enzymes involved in photosynthesis, where its essential function on CO\textsubscript{2} fixation is clearly demonstrated with isolated intact chloroplasts (Borgatto \textit{et al.} 2002) \cite{6}. The potassium found in fertilizers helps to make the stems and straws of plants stronger. Potassium plays a major role in increasing the flower yield and quality. Effect of NPK on various crops and their beneficial effects are well documented in many countries all over the world. This paper briefly discusses the scope and benefits of NPK fertilization on several flower crops.

Concise review of research results
Many flower crops were subjected to different levels of NPK under various researches. Many of these studies revealed that increase in the dose of fertilizers have positively affected the growth and yield of plant and, as well, upgraded the soil and plant nutrient content.

Effect of NPK on soil nutrient status
Mansur (2006) \cite{31} conducted a field experiment entitled “Response of gaillardia (\textit{Gaillardia pulchella} var. \textit{Lorenziana}) cv. Local Double to different levels of nitrogen, phosphorus and potassium and their uptake”, The experiment comprising 24 treatment combinations consisted of four levels of nitrogen (0, 100, 200 and 300 kg N/ha), three levels of phosphorus (0, 75 and
100 kg P₂O₅/ha) and two levels of potash (0 and 75 kg K₂O/ha). The results of the experiment indicated that, the post harvest availability of nitrogen, phosphorus and potash in soil was increased with the increasing doses of fertilizers application and the highest values were recorded with the application of 300 kg N/ha (N₁), 100 kg P₂O₅/ha (P₂) and 75 kg K₂O/ha (K₁) respectively. Joshi et al. (2013) [20] also reported profound effect of NPK fertilization on post harvest availability of soil nutrients during an experiment on chrysanthemum with different levels of nitrogen, phosphorus and potassium. The results indicated that the availability of nitrogen and phosphorus was found to be significant and it was highest with the highest level of nitrogen and phosphorus. Damke and Bhattacharjee (1995) [9] recorded higher organic carbon, phosphorus and potash content in soil with the application of N, P and K fertilization in ‘Super Star’ roses. Similarly, available calcium and magnesium content in soil was influenced by nitrogen, phosphorus and potash fertilization.

According to Nagaraju et al. (2003) [34], application of nitrogen 30 g per plant significantly increased soil available N and application of K to soil significantly increases the soil available K. The soil N, K, Zn and Cu were significantly increased, by the application of N, K and multiplex respectively in rose cv. ‘Gladiator’. Joshi (2005) [18] observed that the availability of nitrogen in the soil was highest (345.23 kg ha⁻¹) with the highest level of nitrogen under chrysanthemum cv. Shyamal cultivation.

Dorajee Rao (2010) [12] in an experiment on the effect of nutrition revealed that the highest available nitrogen was recorded under the treatment N:P:K (200:100:100 kg ha⁻¹) and N:P:K (200:150:100kg ha⁻¹) during both the seasons (Khafir and Rabi) under chrysanthemum cultivation. Bairwa and Yadav (2017) [4] found that among the different doses of NPK applied to the African marigold plant, application of NPK @ 125% RDF recorded significantly higher available N, P and K in soil, over rest of treatments during both the years of experimentation. The conclusion of the study was that the increasing doses of NPK increases the post harvest availability of nitrogen, phosphorus and potassium in soil.

Ravi Teja et al. (2017) [44] conducted an experiment to evaluate the influence of graded levels of nitrogen and potassium combinations on the flower yield of annual chrysanthemum. Significant differences were observed in the interaction effect of nitrogen and potassium with respect to the available nitrogen and potassium content in the soil after harvest. Significantly highest nitrogen (168.00) and potassium (208.00) content in the soil after harvest was observed by application of nitrogen and potassium each at the rate of 200 kg ha⁻¹. Available nitrogen and potassium content in the soil has increased with an increase in the level of nitrogen and potassium applied due to an increase in the fixation of nitrogen and potassium in the soil.

Effect of NPK on plant nutrient content and their uptake
Anuradha et al. (1988) [25] in an experiment observed that the nutrient concentration in African marigold (Tagetes erecta L.) not only varied with different levels of nutrients but also varied during different growth stages. The results revealed that increasing N levels (0 to 90 kg ha⁻¹) significantly increased the N concentration at 30 days after transplanting (30 DAT), 60 DAT and 90 DAT. There was maximum uptake of N, P and K at full bloom stage followed by a decline at harvest stage. Similar results were also reported by Ravindran et al. (1986) [45] in African marigold. They observed that though N levels significantly increased the N concentration in leaves, it decreased at 90 DAT which was attributed to translocation of nutrients to flowers during flowering stage. Singh et al. (2000) [52] reported that the nutrient status (N, P and K content in leaves) of Polianthes tuberosa plants treated with different N, P and K levels significantly increased with the increase in the rate of N, P and K fertilizers, respectively. N, P and K contents in leaves were higher than those in bulbs (rhizomes). Bulb N increased with increasing rates of all fertilizers. Bulb P content was affected by N and P fertilizers, but not by K fertilizer. Bulb K content also increased with increasing rates of all fertilizers. Several studies on different flower crops indicated that there was significant increase in N, P and K concentration with increase in levels of these nutrients. Increase in N level from 0 to 200 kg ha⁻¹ showed an increase in N concentration of marigold from 1.17 to 3.25 per cent (Raja Naik, 2001) [40].

Jamod (2001) [17] reported that the leaf nitrogen of marigold cv. Local Orange was increased significantly from 2.419 to 2.966 and 1.277 to 2.099 per cent with increasing the levels of nitrogen from 50 to 200 kg ha⁻¹ at 60 and 90 days after transplanting, respectively. However, the reduction in leaf content was observed at 60 DAT as compared to 30 DAT. In another study Joshi (2002) [19] found that higher dose of nitrogen (150 kg ha⁻¹) significantly increased the uptake of nitrogen, phosphorus and potassium in chrysanthemum cv. IHR-6. Likewise, phosphorus application at higher rate (100 kg ha⁻¹) significantly increased the nitrogen and phosphorus uptake as compared to lower levels of phosphorus (50 kg ha⁻¹).

Joshi and Barad (2002) [19] reported that P uptake increased with applied N levels up to 150 kg ha⁻¹ and further application of 200 kg N ha⁻¹ reduced the P uptake at final harvest stage. Baboo and Singh (2003) [3] conducted a trial to study the effect of N (125, 250 and 375 kg ha⁻¹) and P (0, 110, and 210 kg ha⁻¹) on African marigold (Tagetes erecta) cv. Pusa Basanti and reported that the N and P content in the leaves and N and P uptake increased with increasing rates of N and P. Sharma (2003) [49] concluded that N, P and K contents before flower bud formation in the plants of both the cultivars of chrysanthemum 'Snow Ball' (standard) and 'Ajay' (spray) were maximum when applied with 45 g N, 30 g each of P₂O₅ and K₂O m⁻². However, there was a decline in N, P and K contents of leaves with graded doses of NPK at the time of flowering. Joshi (2005) [18] observed that application of nitrogen at 300 kg ha⁻¹ recorded highest uptake of nitrogen (197.81 kg ha⁻¹) and phosphorus (49.05 kg ha⁻¹), whereas lower uptake of nitrogen (148.63kg ha⁻¹) and phosphorus (35.10 kg ha⁻¹) was recorded with lower dose of nitrogen in chrysanthemum cv. Shyamal.

Chavan et al. (2010) [7] concluded that the highest nitrogen content of plant at harvest (1.68%) was recorded at 300 kg N ha⁻¹ and uptake of nitrogen at harvest (12.54 kg ha⁻¹) was highest with the application of 200 kg N ha⁻¹ in China aster. Similar findings were reported by Joshi et al. (2012) [21] conducted an experiment on chrysanthemum with three levels of nitrogen (100, 200 and 300 kg ha⁻¹). Nitrogen application at the rate of 300 kg ha⁻¹ significantly improved N, P and K contents of plant parts, as well as uptake of nitrogen. Khalaj et al. (2012) [25] conducted an experiment to study the impact of nitrogen levels (0, 50, 100, 150, 200 and 250 kg ha⁻¹) on plant nutrient content of tuberose and concluded that the maximum nitrogen concentration in plants was recorded under 250 kg ha⁻¹ N whereas maximum phosphorus and potassium...
concentration was recorded under 150 kg ha$^{-1}$ N. Patil (2013) [56] concluded that the application of P$_2$O$_5$ through SSP in roses gives better results in respect to macro and micro nutrient contents and their uptake by plants. Chouhan et al. (2014) [8] studied the effect of NPK on physico-chemical parameters of gladiolus cv. White prosperity. The application of N$_2$P$_2$K$_2$ (4.5:2.7:2.25 g/plant) was observed to be the best in respect of highest nitrogen content in leaves whereas highest phosphorus and potassium content was recorded at an application of N$_2$P$_2$K$_2$ (4.5:1.8:1.8 g/plant) and N$_2$P$_2$K$_2$ (4.5:2.7:1.8 g/plant) respectively. Polara et al. (2014) [58] revealed that application of N and P at higher level significantly increased the nutrient content of marigold in proportion to the supply of their respective element (N at 200 and P at 150 kg ha$^{-1}$) at all the stages of growth. However, K content was not influenced by different P application rates. Shekhawat (2014) [51] in an experiment on “effect of nitrogen and phosphorus on growth and flowering in Tuberose (Polianthes tuberosa L.)” cv. Shringar$^*$ observed that among the interactions, N$_2$P$_2$ (200: 200 kg ha$^{-1}$) recorded the maximum nitrogen and phosphorus content in leaves, while the minimum nitrogen and phosphorus content in leaves were recorded with control. Bairwa and Yadav (2017) [41] found that among the different doses of NPK applied to the African marigold plant, application of NPK @ 125% RDF recorded significantly higher N, P and K content in plants and uptake by plants over rest of treatments during both the years of experimentation, but uptake of Zn and Fe by plants recorded significantly higher with the treatment of NPK @ 100% RDF (200:100:100 kg ha$^{-1}$ of N, P and K respectively) during both the years.

**Effect of NPK on plant growth and yield**

The effect of five levels of N (100, 150, 200, 250 and 300 kg ha$^{-1}$) and four levels of P (0, 100, 150 and 200 kg ha$^{-1}$) was studied in China aster cv. Kamini. The maximum plant height (51.91 cm) and plant spread (21.27 cm) were obtained with highest levels of N, though N at 200, 250 and 300 kg ha$^{-1}$ was at par with each other (Singh and Sangama, 2000) [53]. Rathi et al. (2003) [43] carried out a field trial on African marigold with four different levels of N and found that nitrogen at 30 g m$^{-2}$ gave maximum plant height (73.08 cm) and branches per plant (71.30). Similarly, Sehrawat et al. (2003) [47] studied the effect of nitrogen in African marigold and reported that N increased plant height and N at 30 g m$^{-2}$ gave the greatest plant height (82.10 cm). The number of branches (16.10 and 17.10) was highest with 30 and 40 g N m$^{-2}$. Sharma (2003) [49] studied the response of different levels of nitrogen, phosphorus and potash on the growth and flowering of chrysanthemum (Dendrantha grandiflorum Tzelve) and recorded maximum plant height in both the cultivars ‘Snow Ball’ and ‘Ajay’ with an application each of 30 g N, P$_2$O$_5$ and K$_2$O m$^{-2}$. Maximum number of branches/shoot in the cultivar ‘Ajay’ were found with 30g application of each N, P$_2$O$_5$ and K$_2$O m$^{-2}$. Maximum number of flowers in cultivar ‘Ajay’ was found with 45 g N m$^{-2}$. Also with and application of 30 g each P$_2$O$_5$ and K$_2$O m$^{-2}$ yielded maximum number of flowers per plant. Cut flower having maximum weight was found with 45 g N m$^{-2}$ in cultivar ‘Snow Ball’. Plants supplied with 30 g each P$_2$O$_5$ and K$_2$O/m$^2$ resulted in cut flowers of maximum weight. Acharya and Dashora (2004) [11] conducted a study to find out the effect of graded levels of nitrogen and phosphorus on vegetative growth and flowering in African marigold. Application of 200 kg ha$^{-1}$ each of nitrogen and phosphorus produced the maximum plant height and plant spread. Similar study was conducted by Jamkhande et al. (2004) [10] on China aster and found that the maximum plant height and number of branches was produced with application of 150 kg N and 100 kg P ha$^{-1}$. An experiment was carried out during summer season of 2004-05 to study the effect of different levels of nitrogen on growth, flowering and yield of gaillardia. Application of 150 kg N ha$^{-1}$ resulted in significantly highest fresh weight of all the flowers of five plants and flower yield per plant. The flower yield was maximum (173.83 q ha$^{-1}$) in plots receiving 150 kg N ha$^{-1}$. It was observed that the growth parameters like plant height and number of branches per plant increased with increasing levels of nitrogen from 0 to 150 kg N ha$^{-1}$. Each incremental dose of nitrogen gave significantly taller plant and produced more branches per plant over its preceding doses and the crop fertilized with 150 kg N ha$^{-1}$ gave the maximum value of aforesaid characters (Kanesh, 2005) [23]. Bhat and Shepherd (2006) [5] found that among the different doses of Urea, 200 kg ha$^{-1}$ exhibited the better results in terms of plant height, leaf number per plant, number of branches per plant and plant spread, but further increase in the level of Urea (i.e. 250 kg ha$^{-1}$) was not beneficial and even adversely affected all the parameters. Number of flowers per plant, flower size and weight of individual flower in African marigold were influenced markedly due to different treatments and the maximum number of flowers per plant (49.66) with highest individual flower size (8.10 cm) and weight (14.93 g) was recorded with the highest dose of CAN (250 kg ha$^{-1}$). Gani (2007) [13] studied the effect of nitrogen and phosphorus for better growth of dahlia cv. ‘Kenya Yellow’. They reported that increasing level of N and P$_2$O$_5$ significantly increased the plant spread, number of leaves and branches/ plant. A combination of 80 kg N and 60 kg P$_2$O$_5$ ha$^{-1}$ recorded better for overall growth production of dahlia. Lavhaji (2007) [29] observed that the highest dose of 200 kg N ha$^{-1}$ produced the maximum height, spread and number of primary branches. The results were significant at all the growth stages like 45, 60, 75, 90 and 105 days after planting. Swaroop et al. (2007) [55] studied the influence of nitrogen and phosphorus on growth, flowering and seed yield of African marigold cv. ‘Pusa Narangi Gainda’ at IARI, New Delhi. An application of 120 kg N ha$^{-1}$ was recorded to give maximum plant height, plant spread, and number of primary and secondary branches. Further, application of 75 kg P ha$^{-1}$ recorded maximum plant height and number of secondary branches. Application of 120 kg N in combination with 50 kg P ha$^{-1}$ proved to be optimum and economical for improving plants growth.

Three levels, each of nitrogen (100,200 and 300 Kg ha$^{-1}$) and phosphorus (100,150 and 200 Kg ha$^{-1}$) and a control were tested on the performance of China aster cv. Poornima. Application of nitrogen and phosphorus at their higher levels, i.e. 300 Kg N and 200 Kg P$_2$O$_5$, respectively, resulted in the tallest plant, maximum number of leaves, branches and flowers and thickest stem, largest sized flower, longest flowering duration, maximum fresh and dry weight of flower and the highest yield of flowers (Monish et al., 2008) [33]. Sreekanth et al. (2008) [54] found that among nitrogen application levels, maximum plant height was recorded with 150 kg N ha$^{-1}$ and maximum plant spread and number of laterals were recorded with application of 200 kg nitrogen ha$^{-1}$. Similarly Rajbeer et al. (2009) [41] study the effect of nitrogen on African marigold cv, Pusa Narangi Gainda. The results revealed that the maximum plant height (67.76 cm)
and plant spread (49.88 cm) were recorded at an application of 100 kg urea ha\(^{-1}\), while maximum number of primary branches/plant (18.15), number of flowers per plant and flower yield (q/ha) was observed at higher level of nitrogen (150 kg urea ha\(^{-1}\)), followed by application of 100 kg urea ha\(^{-1}\).

The investigation entitled “Nutritional studies in Barleria cristata Linn.” was carried out at experimental farm of the Department of Floriculture and Landscaping, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during the year 2008. Vegetative parameters like plant height, number of primary side shoots per plant, number of secondary side shoots per plant, plant spread and number of leaves per plant were found to be best with 30 g m\(^{-2}\) each of nitrogen, phosphorus and potassium whereas flower characters like number of flowers per cluster and number of flower clusters per plant were found to be best with 15 g m\(^{-2}\) nitrogen and 30 g m\(^{-2}\) each of phosphorus and potassium (Sharma, 2009). A field experiment entitled “Performance of China aster (Callistephus chinensis Nees.) varieties and their response to different levels of nitrogen”, was conducted during rabi season of 2005-06. All the vegetative characters were greatly influenced by nitrogen at 300 kg ha\(^{-1}\). It had recorded highest plant height, plant spread, number of primary branches per plant, fresh weight and dry weight of plants (Chavan et al., 2010)\(^{[7]}\).

Ghosh and Pal (2010)\(^{[14]}\) studied the effect of different levels and sources of nitrogenous fertilizer on African marigold (Tagetes erecta Linn.) cv. Siracle, on sandy loam soil. Maximum plant height, number of primary branches and number of secondary branches were recorded at an application of 300 kg ha\(^{-1}\). Flower diameter, individual flower weight and flower yield were directly related to nitrogen level. Flower yield increased significantly with increase in nitrogen fertilization from 100 to 200 kg N ha\(^{-1}\). Jadhao et al. (2010)\(^{[15]}\) revealed that the vegetative growth in respect of height of plant, number of leaves per plant and number of primary shoots per plant were increased with increasing levels of nitrogen. Maximum growth was obtained with application of 30 g nitrogen per metre square in gerbera. Similarly Kumar et al. (2010)\(^{[28]}\) recorded maximum plant height (84.97 cm), number of branches/plant, number of leaves/plant, number of flowers per plant and maximum number flower yield of flower heads per hectare with the application of 240 kg nitrogen per hectare, followed by application of 120 kg nitrogen per hectare in African marigold cv. Pusa Narangi Gainda. Pal and Ghosh (2010)\(^{[14]}\) conducted an experiment to investigate the sources (as potassium chloride and potassium sulphate) and optimum potassium level (0, 50, 100, 150 and 200 kg ha\(^{-1}\)) for irrigated African marigold. Plant height and yield of flowers increased with increasing levels of potassium fertilization from 0 to 200 kg ha\(^{-1}\). It was also revealed that the sources of potassium failed to influence plant growth and yield parameters.

Field experiments were conducted to study the response of graded levels of N and P\(_2\)O\(_5\) on flowering and yield of African marigold. A pronounced response of nitrogen application was evident at 150 kg ha\(^{-1}\) level in respect of important yield attributing parameters viz., number of flowers per plant, individual flower weight (g), flower size (cm) and flower yield ha\(^{-1}\). Further increment in N application caused significant reduction in values for all the traits except flower size (Sharma et al., 2010)\(^{[48]}\). Karetha et al. (2011)\(^{[24]}\) conducted an experiment on gaillardia with 24 treatment combinations i.e. four levels of nitrogen (0, 100, 200 and 300 kg N ha\(^{-1}\)), three levels of phosphorus (0, 75 and 100 kg P\(_2\)O\(_5\) ha\(^{-1}\)) and two levels of potash (0 and 75 kg K\(_2\)O ha\(^{-1}\)). Results exhibited that maximum flower yield was observed with the fertilizer application rate of 300 kg N ha\(^{-1}\), 100 kg P\(_2\)O\(_5\) ha\(^{-1}\) and 75 kg K\(_2\)O ha\(^{-1}\). Kokate et al. (2011)\(^{[20]}\) carried out an experiment to study the “Effect of nitrogen and potassium on growth, flower yield and quality of golden rod”. The results revealed that highest plant height was recorded at higher level of nitrogen i.e. 150 kg N ha\(^{-1}\) which was followed by the treatment of 100 kg N ha\(^{-1}\), whereas, treatment under control had produced significantly minimum plant height. An application of 150 kg ha\(^{-1}\) each of nitrogen and potassium produced maximum number of inflorescence flower stalk and maximum durability of inflorescence in situ. Whereas, maximum spread of inflorescence, and yield of flower stalks ha\(^{-1}\) were recorded under the treatment 150 kg N ha\(^{-1}\) and 100 kg K\(_2\)O ha\(^{-1}\).

Pushkar and Rathore (2011)\(^{[39]}\) reported that the application of 200 kg N, 80 kg P\(_2\)O\(_5\) and 80 kg K\(_2\)O ha\(^{-1}\) resulted significantly maximum plant height and number of primary branches per plant (94.26 cm and 20.73 cm) respectively as compared to control in African marigold. Dorajee Rao et al. (2012)\(^{[11]}\) in a study revealed that with every increase in nitrogen level, at a constant level of phosphorus there was increase in plant height. Number of branches, number of leaves and leaf area per plant were recorded maximum with 150 kg nitrogen + 100 kg phosphorus in garland chrysanthemum. Joshi et al. (2013)\(^{[20]}\) studied the effect of different levels of nitrogen on chrysanthemum varieties IHR and 75 kg K\(_2\)O resulted in the highest plant height, number of branches per plant, leaf area and fresh and dry weight of plant.

The growth parameters in Dendrobium orchid cv. Sonia 17 like plant height, number of leaves per plant, leaf area, number of shoots per plant, number of pseudobulbs per plant, number of back bulbs per plant, shoot diameter and internodal length recorded the highest value in the treatment which received NPK nutrients of 20:10:10 at 0.2% (Patnaik et al. 2013)\(^{[37]}\). Kumar and Kumar (2014)\(^{[27]}\) conducted an experiment on China aster with four levels each of Nitrogen (0, 100, 200 and 300 kg ha\(^{-1}\)) and phosphorus (0, 100, 150 and 200 kg ha\(^{-1}\)). The application of N.P.O\(_3\) (300kg N ha\(^{-1}\) and 200 kg P\(_2\)O\(_5\) ha\(^{-1}\)) was observed to be the best in respect of plant height, number of primary branches, number of leaves per plant, flower weight, flower diameter and flower yield.

Shekhawat (2014)\(^{[51]}\) during an experiment on effect of nitrogen and phosphorus on growth and flowering in tuberose (Polianthes tuberosa L.) cv. Shringar concluded that the yield characteristics were significantly influenced by different levels of N and P treatments. The earliest first spike emergence, longest duration of flowering, the maximum number of spikes per plant, maximum length of spike, maximum diameter of florets, maximum length of florets and maximum number of florets per spike were recorded with N\(_1\) and P\(_1\) (200: 200 Kg ha\(^{-1}\)). Dinesh (2015)\(^{[10]}\) carried an experiment at Dr. Y.S. Parmar university of Horticulture and forestry, Nauni, Solan (H.P.) during 2014 to optimize the dose of nitrogen and potassium on growth, flowering and multiplication of Dahlia (Dahlia variabilis) cv. ‘Giani Zail Singh’. Maximum plant height, duration of flowering, stem length and total number of tuberous roots per plant was recorded best when nitrogen applied at the rate of 30 g m\(^{-2}\) along with potassium at the rate of 24 g m\(^{-2}\). With a view to study the effect of nitrogen and phosphorus on growth and flowering of French marigold cv. Pusa Arpita an
experiment was conducted. During all the different stages (30, 45 and 60 days after transplanting) of observation T₈ (Nitrogen 80 kg ha⁻¹ + Phosphorus 40 kg ha⁻¹) showed better result in term of plant height, plant spread, number of leaves per plant, number of primary branches per plant, number of secondary branches per plant and stem diameter (Rajput, 2015) [42]. Sanghamitra et al. (2015) [46] studied the effect of different sources (MOP and sulphate of potash) and levels of K₂O (0, 40, 80, 120, 160, 200 and 240 kg ha⁻¹) on flower yield and carotenoid content in African marigold. Based on the results obtained it was concluded that K₂O applied at the rate of 240 kg ha⁻¹ in the form of sulphate of potash recorded significantly highest flower yield per hectare (223.66 q ha⁻¹). Maheta et al. (2016) [100] observed that both the highest levels of N and P significantly improved growth and yield parameters i.e. plant height, plant spread, secondary branches per plant, fresh weight, dry weight, flowering span, number of flowers per plant and yield of flowers in treatment N₄ (300 kg N ha⁻¹) whereas, in case of phosphorus the plant height, plant spread, number of branches per plant, fresh weight, dry weight, flowering span, number of flowers per plant and yield of flowers was noted in treatment P₃ (200 kg P₂O₅ kg ha⁻¹).

Thakur (2016) [56] observed that the plant, number of primary branches, leaves and root suckers per plant increased significantly, with increase in nitrogen dose (urea) from 100 to 500 mg/pot in cv. Kikiobiory, Snowball and Amnol of chrysanthemum. Ravi Teja et al. (2017) [44] in a study revealed that plant height, number of primary branches, number of secondary branches, plant spread, number of leaves, dry weight and number of flowers per plant or per plot or per hectare was found significantly maximum with the application of nitrogen at the rate of 200 kg ha⁻¹ in combination with potassium applied at the rate of 150 kg ha⁻¹ along with common dose of application of phosphorus at the rate of 100 kg ha⁻¹. Mishra et al. (2018) [32] revealed that among all the treatments, the interaction of N₃P₁ (150 kg h⁻¹ N and 90 kg h⁻¹ P) produced significantly tallest plant, highest plant spread with maximum number of branches and more number of leaves per plant in china ester. The maximum number of flowers, flower diameter, fresh weight of flower, dry weight of flower, flower yield per plant, per plot and per hectare was also recorded with the interaction of N₃P₁ (150 kg ha⁻¹ N and 90 kg ha⁻¹ P).

Conclusion
It can be concluded from the study that nitrogen, phosphorus and potassium enhanced the soil and plant nutrient content, their uptake, vegetative as well as yield attributes of flower crops. Proper nutrition through optimum doses of fertilizers is much more important for better yield and quality of flowers.

Future prospects
Application of major nutrients viz., nitrogen, phosphorus and potassium play an important role in growth and development of many flower crops, thereby increase the flower yield. Therefore, further research should be conducted to determine the optimal and economic rates of application of nitrogen, phosphorus and potassium in the form of manures, composts and inorganic fertilizers.

References


44. Ravi Teja P, Bhaskar VV, Dorajeerao AVD, Subbaramamma P. Effect of graded levels of nitrogen and potassium on growth and flower yield of annual...


