Balanced Fertilization for Important Cut Flower Crops

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All over the world, the floriculture sector undergoes rapid changes. Due to globalization and its effect on income development in different regions of the world, growing per capita consumption in most countries is realized. The export of floricultural products from India has been on the increase in the past five years with the introduction of new floriculture products and ever increasing demand from the importing countries. This warrants efforts to boost the productivity and quality of the produce which meet the required international standards. To ensure maximization of productivity in any crop, balanced nutrient supply is an important factor and these cut flowers are not an exception. Efficient nutrient use results from balanced fertilization and sound management practices. When balanced fertilization is practiced, it increases the efficiency of others through a synergistic effect. The balanced fertilization in important cut flowers is discussed below:

Rose

Rose is an important cut flower appreciated as Queen of flowers. Under field conditions, roses respond well to fertilizer application. In addition to the basal dose of well decomposed FYM, rose requires 200-400 kg of N/ha. This dose may be split into two, once at pruning and the second dose after about 20 days. The requirement of phosphorus and potash can be met by adding 150 kg/ha of each at the time of pruning.

The above basal dose of fertilizers is supplemented with foliar feeding ; consisting of 2 parts urea, 1 part dihydrogen ammonium phosphate, 1 part potassium phosphate and 1 part potassium nitrate. 3 g of this mixture dissolved in l of water is sprayed at one week or 10 days interval till flowering. Micro nutrients @ 1 part each of ferrous sulphate, manganese suplhate, magnesium sulphate and borax ¼ part is mixed and sprayed at the rate of 1 g/l water from two months after planting.

Field grown roses for cut flower require different nutrients. Application of NPK @ 50, 150, 75 g / m^2 has been recommended for rose cultivar 'Happiness' under Bangalore conditions. Cultivar 'Super Star' receiving 30:12:12 g / m^2 of N : P : K along with 6 or 12 g multiplex responded best in terms of growth, yield and quality of cut roses.In soils deficient in micronutrients, foliar application of a solution prepared from the mixture containing 15 g manganese sulphate, 20 g magnesium sulphate, 10 g chelated iron and 5 g borax at the rate of 2 g/l has been found effective for obtaining good quality foliage and flowers. The concentration of spray solution should never exceed 0.3%.

Gurav *et al*. (2004) observed in 'First Red' cultivar of rose that 400: 200: 200 ppm NPK / plant / week increased the yield of flowers under Pune conditions. Integrated nutrient management tried in rose (Singh and Jauhari, 2005) found the flower production to be influenced by N, Azotobacter and application of FYM (Table 1).

Table 1. Effect of N, *Azotobacter* and FYM on flowering attributes in ROSE

Treatment	Days taken to bud appearance	No. of flowers/m^2 during I flush	No. of flowers/m^2 during II flush	Weight of flowers/m^2 I flush(g)	Weight of flowers/m^2 II flush(g)
20g/m^2	116.14	103.75	195.17	464.57	814.54
40g/m^2	111.24	103.33	210.42	463.90	859.27
60g/m^2	124.01	166.25	226.67	493.58	1081.59
CD at 5%	6.86	12.83	1.52	40.70	43.57
Azotobacter					
Uninoculated	106.63	101.11	199.11	427.56	851.58
Inoculated	127.64	114.44	222.39	508.47	985.35
CD at 5%	5.60	10.48	1.24	33.23	35.57
Levels of					
FYM	106.52	104.78	206.83	448.33	916.05
O Kg/m^2	127.75	110.78	214.67	487.70	920.87
5 Kg/m^2	5.60	NS	1.24	33.23	NS
CD at 5%					

Carnation

Carnation is one of the important cut flowers of the world. The demand is increasing day by day, but the flowers of carnation with proper stalk length, with appropriate size in desired number per plant are not available. Nutrient management plays an important role in production of carnation. An average carnation plant contains 434 mg N, 81 mg K; 253 mg Ca, 74 mg Mg and 46 mg S. Apart from major nutrients like N, P and K, Ca, Mg, B and Fe also play a crucial role in carnation nutrition.

At the time of land preparation sufficient quantity of organic manure must be added. A basal dose of N, P, K at the rate of 20:20:10 g/m^2 is applied three weeks after planting. Fertigation is done with N at 100 ppm and K at 140 ppm twice in a week along with other nutrients like Ca, Mg, Fe, B, Mn, Cu and Zn. Excess potassium cause magnesium and boron deficiency. Carnations are very sensitive to boron deficiency. It may cause excessive calyx splitting and abnormal opening of flower buds. Iron, manganese, boron, copper and zinc are taken as a source from Fe-EDTA, manganese sulphate, boric acid, copper sulphate, zinc sulphate and applied in 30 mg/l, 2.3 mg/l, 2.5 mg/l, 0.98 mg/l and 6 mg/l concentrations, respectively (Singh, 2006).

In TNAU, it was found with cv. Malaga that application of 2 % Panchagavya + 4 % Manchurian mushroom tea in addition to common basal dose of FYM 2 kg/m^2 / yr + DCC 200 g/m^2 + *Azospirillum* 2 g + *Phosphobacteria* 2 g + VAM 2 g / plant at 2 month intervals + *Trichoderma* 20 g /m^2 /year resulted in good vegetative growth, flowering, yield and quality attributes (Table-2). Flowers obtained from this treatment when pulsed with 10% sucrose + 1mM STS + 300 ppm $Al_2 (SO_4)_3$ + 25 ppm BAP, treated with a holding solution consisting of 300 ppm $Al_2 (SO_4)_3$ and wrapped in polyethylene sleeves of 100 gauge thickness recorded the longest post harvest life under Ooty conditions. (Punitha, 2007).

Table 2. Effect of biostimulants on number of flowers and petals in carnation

Treatments	Number of flowers/ plant	Number of petals/ flower
T_1 - Panchagavya – 2%	7.47	56.27
T_2- Manchurian mushroom tea – 4%	9.03	56.53
T_3 - T1 + T2	11.53	73.83
T4 - Control	7.23	52.63
CD at 5%	0.420	0.940

Sunita Devi *et al.* (2005) reported that number of days taken for initiation of floral bud in carnation was not altered by the application of N & P. But increased levels of N reduced the number of days taken for opening of flower bud besides improving the yield (Table 3 and 4).

Table 3. Effect of nitrogen and phosphorus on number of days taken for opening of Carnation flower from the date of bud initiation

Treatments	Levels of phosphorus (g/m^2)			
Levels of nitrogen	0	10	20	Mean
0	27.30	25.50	24.66	25.82
10	23.58	23.38	23.11	23.36
20	22.77	19.30	19.08	20.38
30	19.05	18.80	**18.49**	19.78
CD at 5%	N = 4.57, P = NS, N x P = NS			

Table 4. Effect of nitrogen and phosphorus on number of flowers per plant in Carnation

Treatments	Levels of phosphorus (g/m^2)			
Levels of nitrogen	0	10	20	Mean
0	0.83	1.40	1.83	1.35
10	2.08	2.00	2.66	2.25
20	3.00	3.16	3.66	3.27
30	4.17	4.33	**4.86**	4.45
CD at 5%	N =1.61, P = NS, N x P = NS			

Anthurium

Anthurium is grown for its colourful showy longlasting flower and foliage. For better growth of the plants manuring with dried cow-dung once in a month during the period other than rainy season is followed. In rainy season application of cow-dung causes excess water retention thereby favouring development of fungal growth and mould leading to danger for plant survival. Therefore, in rainy season instead of cow dung, powdered goat manure is fortified with 2-3 g dolomite per pot.

Fertilization is done by means of foliar application upto age of four month. Fertilizers like NPK in ratio of 30:10:10 may be sprayed at 0.05% as a foliar application twice a week. In later stages it should be sprayed at 0.5% once a week. Calcium, magnesium and sulphur are other important elements required in anthurium nutrition.

Split application of nitrogen, phosphorus and potassium at 30, 20 and 50 g/m^2 at 3, 6 and 9 months after planting increased number of suckers, stalk length, length and width of spathe, number of flowers per plant, improved flower weight and resulted in early flowering. Calcium deficiency causes colour break down of the spathe which can be corrected by the application of calcium nitrate @ 5 g per m^2 (Singh, 2006).

In TNAU, application of NPK @ 30:10:10 at 0.2 per cent spray + *Azospirillum* + phosphobacteria + VAM + GA_3 200 ppm in anthurium cultivar 'Temptation' has been found to influence the number of flowers per plant, besides improving the floral attributes (Table 5, Padmadevi and Jawaharlal, 2004).

Table 5. Effect of nutrients, biofertilizers, and growth regulator on flower production in *Anthurium andreanum* cv. Temptation

Treatments	Number of flowers/plant
T_1 - NPK @ 30:10:10 at 0.2 % spray and GA_3 200 ppm	1.33
T_2 - T_1 + *Azospirillum*	2.33
T_3 - T_1 + Phosphobacteria	3.67
T_4 - T_1 + VAM	3.67
T_5 - T_1 + *Azospirillum* + Phosphobacteria	3.33
T_6 - T_1 + *Azospirillum* + VAM	3.33
T_7 - T_1 + Phosphobacteria + VAM	4.00
T_8 - T_1 + *Azospirillum* + Phosphobacteria + VAM	5.67
T_9 - NPK @ 15:10:10 at 0.2 % spray and GA_3 200 ppm + *Azospirillum*	3.33
T_{10} - NPK @ 30:5:10 at 0.2 % spray and GA_3 200 ppm + Phosphobacteria	4.00
T_{11} - NPK @ 30:5:10 at 0.2 % spray and GA_3 200 ppm + VAM	3.00
T_{12} - NPK @ 15:5:10 at 0.2 % spray and GA_3 200 ppm + *Azospirillum*+ Phosphobacteria	4.00
T_{13} - NPK @ 15:5:10 at 0.2 % spray and GA_3 200 ppm + *Azospirillum* + VAM	3.33
T_{14} - NPK @ 30:0:10 at 0.2 % spray and GA_3 200 ppm + Phosphobacteria + VAM	4.00
T_{15} - NPK @ 15:0:10 at 0.2% spray and GA_3 200 ppm + *Azospirillum* + Phosphobacteria + VAM	4.33
T_{16} - Control (no fertilizer + no biofertilizer)	0.33
SE (d) CD (p=0.05)	0.39 0.79

Further study was conducted in TNAU to investigate the effect of nutrients and growth regulator on flowering in Anthurium (Table 6, Anand and Jawaharlal, 2004).

Table 6. Effects of nutrients and growth regulators on days to first flowering in Anthurium

Fertilizer(F)	Growth regulator(G)				Mean
	BA 250 ppm	BA 250 ppm	GA_3 250 ppm	GA_3 250 ppm	
Control	269.20	269.00	270.20	268.30	269.18
NPK@ 20:20:20 at 0.25%	245.00	241.00	225.00	230.00	235.25
NPK@ 20:20:20 at 0.50%	250.00	248.00	230.00	233.00	240.25
NPK@ 20:20:40 at 0.25%	210.00	215.00	186.50	198.00	202.38
NPK@ 20:20:40 at 0.50%	235.50	230.00	210.50	215.00	222.75
NPK@ 20:40:40 at 0.25%	205.00	210.50	220.00	223.45	214.74
NPK@ 20:40:40 at 0.50%	235.00	230.00	225.00	234.00	231.00
Mean	235.67	234.79	223.89	228.82	

	F	G	F X G
SE(d) :	0.72	0.54	1.43
CD(5%) :	1.47	1.11	2.93

Foliar spray of both nutrient solutions and growth regulators drastically reduced the number of days taken for inflorescence emergence to spathe unfurling (Table-6). The nutrient level NPK @ 20:20:40 @ 0.25% with growth regulator GA_3 at 250 ppm took the lowest period of 186.50 days to reach flowering as well as inflorescence emergence to spathe unfurling.

Chrsanthemum

Chrysanthemum is one of the important flower crops of the family Asteraceae. The standard types are used as cut flowers. It is well known fact that the successful growth and flowering depend upon the application of balanced nutrition. Since

Chrysanthemums are heavy feeders of nutrients, use of NPK plays an important role from the beginning. TNAU recommends farm yard manure @ 25t/ha + 125:120:25 kg NPK/ha, half of the N and entire dose of P & K are to be applied basal before planting. The other half of N is to be applied 30 days after planting. The same dose has to be repeated if a ratoon crop is allowed. Experiments conducted with integrated nutrient management revealed that the plants supplied with 50% of recommended dose fertilizers (RDF = 125: 120: 120 kg / ha) + vermicompost (5 t/ha) + 3% Panchagavya was superior in respect of all the economic floral parameters (ICAR Annual report, 2006 – 07, Table 7).

Table 7. Integrated nutrient management studies in chrysanthemum cv.CO1

S. No.	Treatments	Days taken for first bud appearance after planting	No. of flowers/ spray/ plant	Flower diameter (cm)
1.	100% of Recommended dose of FYM and inorganic fertilizers (RDF) (control)	64.55	71.54	1.01
2.	50% (RDF)	65.13	73.27	1.26
3.	50% RDF + 3% Manchurian tea	63.36	81.49	1.64
4.	50% of RDF + 3% Panchagavya	61.92	83.53	2.15
5.	50% of RDF + 3% Panchagavya + 3% Manchurian tea	60.76	89.44	2.55
6.	50% RDF + vermicompost (5 t / ha)	56.89	104.16	4.03
7.	50% of fertilizers + vermicompost (5 t / ha)+ 3% Manchurian tea	59.34	95.96	3.58
8.	50% of fertilizers (500 g/m^2 - twice a year) + vermicompost (5 t / ha) + 3% Panchagavya	54.23	110.36	4.77
	CD (P=0.05)	3.17	2.98	0.24

Gerbera

Gerbera is one of the majestic floricultural crops grown for its cut flower. Application of balanced nutrients plays a prime role in its production.. Phosphorus and Calcium are best given before planting as a basal dressing. Depending upon the Ca levels in the soil, P can be given as TSP (triple super phosphate) or SSP (single super phosphate). Application of 15 g N, 20 g P_2O_5 and 20 g K_2O / m^2 yielded maximum number of flowers per plant in poly house conditions. Magnesium can be given in the form of finely powdered dolomite limestone if pH also needs to be raised. Magnesium can also be added in the form of water soluble magnesium sulphate, either before or after planting (Singh, 2006).

Being a cut flower grown under green house, fertigation holds good. Different researchers have tried to determine the best ratio in N, P and K and their results varied from ratios 1:1:1 to 3:1:5. This indicates that there is no perfect mix but the right fertilizer regime depends on several conditions. Young vegetative plants require a ratio as 20:20:20 or 18:18:18 for the development of a strong root system and foliage. When the plants start to flower, the ratio should be increased in its level of K to increase flower production. Under open ventilation and fan pad system of poly houses, supply of 150 ppm of N, 60 ppm of P_2O_5 and 150 ppm of K_2O per plant on alternate day produced maximum flowers per plant.

Scheduling is done in such a way that up to 2-3 weeks after planting, no fertilizers are applied. From 3-12 weeks, N:P:K with ratio of 20:20:20 should be applied at 0.75 g/l/day and from 12 weeks onwards, 15:8:35 at 1-1.5 g /l/day can be applied. This is a general schedule that has to be amended by taking and analyzing soil samples at regular intervals. Total soluble salt levels (electrical conductivity level) for gerberas should be less than 2 mhos x 10^{-3} at 25^0 C (Singh, 2006).

Maximum number of flowers /plant and per sq. m. was recorded with improved floral characters when applied with higher levels of N & P (10 N + 15 g P_2O_5 / m^2). Maximum flower diameter and vase life were obtained with N & P levels of 10 g N + 12. 5 P_2O_5 g /m^2 and 5 g N + 15 g P_2O_5 /m^2 respectively (Pimple *et al*. 2006).

Gladiolus

Gladiolus is an important bulbous plant cultivated for its beautiful spike and appreciated as cut flower. For successful cultivation nutrient management is of prime importance to obtain good quality flowers.

Corms of gladiolus are rich in stored food which is sufficient to sustain plant growth for initial few days. Though cormels require fairly good amount of fertilizers due to their small size, the macronutrients are needed in large quantity. Organic manure should be mixed through the top soil before planting to improve the structure of the soil. Nitrogen should be applied at 300 kg/ha which may be reduced in medium and heavy soils. It is applied in two doses, first at 3 leaf stage and second at 6 leaf stage. Cormels may be given with nitrogen in 4-5 applications at about 3 weeks intervals starting from one month age of the crop. Mainly N should be applied in nitrate form and application should be stopped at least six weeks prior to harvesting the corms. Phosphorus should be given as basal dose ranging from 150-200 kg/ha depending upon soil test. In heavy soils phosphorus application should be delayed till plants reach 2-3 leaf stage and develop good root system. Potassium imparts resistance to diseases and increases photosynthetic efficiency of leaves. Gladiolus requires around 120-150 kg K_2O/ha at the time of planting of corms.

Vikrant kumar (2006) reported that P levels of 200 kg/ha resulted in maximum vegetative growth, no. of flowers per plant and no. of spikes per corm.

Iron deficiency is common in north-west plains of India and causes interveinal yellowing of new leaves. The deficiency is more pronounced in alkaline soils and in severe conditions emerging spikes turn light green to yellow. This can be corrected by spraying ferrous sulphate at 0.2 per cent, twice or thrice at 10 days interval.

Orchids

Orchids are one of the best known cut flowers. Regular scheduling of nutrients is important for its consistent production and improved quality. The type of nutrients, their quantity and frequency of application depend largely on the type of orchid, potting medium, season of the year, growing conditions, stage of development of the plant, etc.

Since most of the cultivated orchids are epiphytic in nature, the media used are highly porous. Hence, if the nutrients are applied in the media, the nutrients are leached down, making it unavailable to the plants. Hence, in orchids, foliar feeding is ideal. Small quantities of fertilizers should be applied in shorter intervals than using large quantities at longer intervals. This helps the plants to grow steadily without any deficiency throughout their growth period. The quantity also depends upon the frequency of application. Since inorganic fertilizers are applied as foliar spray, the quantity of nutrients used per plant should be relatively very low, otherwise it will be toxic to the plants. For younger plants the concentration should be very low. During rainy period also the requirement is low. In the case of plants that are transplanted or freshly planted, no fertilizer application is necessary till new roots are formed. A fertilizer complex containing nitrogen, phosphorus and potash in equal proportion (like 17:17:17 complex) is ideal for general application. The concentration may be adjusted between 0.2 and 1.0 per cent depending upon the situation. However another recommendation is during vegetative phase a 30:10:10 combination of N, P and K should be used which may be changed to 10:20:20 formulation during flowering stage. A concentration of 0.2% should be sprayed twice a week.

Organic manures like cow-dung, neem oil cake, poultry manure, etc. are also used for orchids. These are found to be more ideal for monopodial types. These may be soaked in water for 4-5 days for fermentation, diluted 10-15 times with water, filtered and sprayed over the plants. Fresh coconut water, cow’s urine (1:20-25 with water) are also useful as foliar spray.

The frequency of application could be from thrice a week to once in two weeks under tropical conditions, though twice a week is the usual recommendation. The type and quality of nutrient and their application time play an important role on the quality of flowers. As flower buds begin to form interior sheaths, a mixture containing more of phosphorus is useful in improving the quality of spike. Application of inorganic fertilizer should be stopped about three days prior to harvest of spikes since it may otherwise reduce the shelf life of flowers.

At TNAU, application of 50% of Recommended dose of fertilizers (RDF) (NPK 30:10:10 @ 0.2% twice a week + FYM spray @ 1:10 ratio once a week) + 3%

vermiwash + 3% panchagavya in Dendrobium variety Sonia 17 was found to be superior in respect of all the vegetative parameters as well as flowering parameters including vase life (Table 8, ICAR Annual report, 2006 – 07).

Table 8. Integrated Nutrient Management in Orchid- *Dendrobium*

Treatments	Plant height (cm)	Internodal length (cm)	Days to flowering
NPK 30:10:10 @ 0.2%*	34.7	2.98	199.42
NPK 30:10:10 @ 0.1% *	31.2	3.12	210.45
NPK 30:10:10 @ 0.1% *+ 3% vermi wash +3% panchagavya	34.4	3.00	197.65
CD (P=0.05)	2.9578	0.5621	13.9150

- *at twice a week + FYM spray @ 1:10 ratio once a week (non flowering stage)*

As Dendrobium is epiphytic in nature, the media or substrate may be devoid of nutrients and it necessitates a regular schedule of fertilizing in liquid form. In Dendrobium hybrid New pink x Emma, maximum no. of shoots (5.5) were produced by spraying with NPK 30:10:10 at 0.2 per cent and 17:17:17 at 0.1 per cent level as alternate sprays (Sobhana *et al*. 2004).

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