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Research Article

# Response of Carnation to Potassium Fertilizer Sources and Levels Under Polyhouse Conditions

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## Abstract

Potassium (K) is quality element for cut flowers. To find out K fertilizer source and level suitable for carnation variety '*kiro*' as well as to study growth, flowering and economics. The experiment was laid out in factorial randomized block design (FRBD) with 12 treatments (3 sources and 4 levels) and 3 replications under polyhouse condition at College of Agriculture, Pune. The sources of K were: $S_1$-KCl, $S_2$-$K_2SO_4$ and $S_3$- $KNO_3$ while the levels were: L1-75,225; L2-100,250; L3-125,275 and L4-150,300 mg $K_2O$ per plant during vegetative (D1) and flowering (D2) period, respectively. Significantly higher growth influenced by KCl (S1), as compared to $KNO_3$ ($S_3$) and $K_2SO_4$ (S2). However, flower yield, quality, vase life and B: C ratios were higher for $K_2SO_4$ ($S_2$) than KCl ($S_1$) and KNO3 ($S_3$). Between interactions maximum laterals in $S_1L_3$ and least recorded at S3L4. Fifty percent flowering were observed in S1L4 interactions. Higher revenue, net profit and B: C ratio was obtained in $S_2L_2$. Higher efficiency of $K_2SO_4$ associated with the lower level of application revealed the tendency of carnation to take up as much nutrients (potassium and sulphur) as possible without exceeding the limits under limited supply. The results revealed that the $K_2SO_4$ ($S_2$) @ 100 mg $K_2O$ per plant during vegetative growth ($D_1$) and @ 250 mg $K_2O$ per plant after flowering ($D_2$) along with N and P is superior over KCl ($S_1$) and $KNO_3$ ($S_3$) for carnation.

**Keywords:** Potassium Fertilizers; Carnation; Growth; Yield; Quality; Economics

## Introduction

Among the cut flowers carnation (*Dianthus caryophyllus* L.) has tremendous potential in the international flower market with trade of $93.42 million. It is important commercial cut flower, which ranks second after rose [1]. It is preferred to roses and chrysanthemum in several exporting countries, due to its wide range of colour, excellent keeping quality, ability to withstand long distance transportation and remarkable ability to rehydrate after continuous shipping. International market survey indicated that approximately 51% of the people who favored roses as preferred flower compared to only 19% of the total number of consumers expressed their liking for carnation [2]. However, carnations are considered to be cardio tonic, diaphoretic and alexiteric [3]. It is extensively cultivated in 191 countries with an area 6000 ha for production of cut flowers. The major exporters of carnation are Columbia, Netherlands, and Israel while the major importers of carnation are Federal Republic of Germany, France, and UK [4]. In India, carnation is mostly grown in adjoining areas of Ludhiana, Nasik, Pune, Delhi, Bangalore cities and in Kashmir [5].

Commercial production of cut flowers especially under polyhouse conditions for export is gaining lot of importance in last two decades. Floricultural industry is increasing at the compound annual growth rate of 30% (2010-11), with mushrooming growth of small polyhouse in India during last two decade. The total estimated area under floriculture in India is about 309'260 ha with Jammu and Kashmir as a leading state having an area of 51,770 ha. The Maharashtra state which shows steady increase in floriculture industry, at present have an area of 12230 ha. The international floriculture trade is estimated of $ 40 - 60 billion and Indian market share in the global flower trade is about Rs 548.74 Crores (82.05 $ millions) which is less than 0.21 per cent. Hi-technology cultivation of flowers in protected conditions is currently having an area of about 500 ha in India [6], out of which Maharashtra's share is about 150 ha. Area under carnation in Maharashtra is 14.2 ha with production capacity of 1,19,800 numbers of flowers per day [7]. Areas spread in Pune, Nashik, and Sangli mostly owned by corporate and small farmers, who produce carnations for the national and local market. With the available resources, economical and high quality flower production is one motto for maximum net profits. Application of different sources and levels of fertilization practices after standardization can be one of the means to achieve the target of top quality flower.

Carnation is dominantly cultivated under protected conditions for obtaining higher yield and better quality. However, the exact nutritional requirements of carnation grown under raised bed conditions of polyhouse not clearly understood. Considering the above wide scope and potential of carnation as cut flower. The present experiment with the following objective of to assess the effect of different sources and levels of K on growth, yield and quality of carnation as well as economics under polyhouse conditions.

## Materials and Methods

Carnation variety '*kiro*' planting material was procured from M/s. Germini Agro (P) Ltd, Mumbai. The study was conducted at 180.32' N latitude and 730.51' E longitude at an altitude of 930 meters above MSL (Hi-tech Floriculture Project, College of Agriculture, Pune) in red sandy loam soil. The experiment was laid out in the factorial randomized block design (FRBD) with 12 treatments (3 sources x 4 levels of potassium fertilizers) and replicated 3 times with 16 plants per treatment. The sources of K were: $S_1$-KCl, $S_2$-$K_2SO_4$ and $S_3$-$KNO_3$ while the levels were: L1-75,225; L2-100,250; L3-125,275 and L4-150,300 mg $K_2O$ per plant and 200:70, 120:60 mg N and $P_2O_5$ during vegetative ($D_1$) and flowering ($D_2$) period, respectively. The dimension of the bed on which experiment were conducted was 26m length, 0.90m width and 0.30m height. The plot size was 0.75m x 0.60m. rooted cuttings of carnation were planted at a spacing of 15 x 15 cm.

Growth, flower yield and quality (vase life) parameters were recorded from five randomly selected plants of net plot per treatment using standard procedure. The calculated average values were subjected to statistical analysis using analysis of variance method. Using test of significance (F-test) critical differences (CD = 0.05) were also worked out. Duncan's multiple range tests was adopted for ranking the treatment analysis. The cost of cultivation was worked out treatment-wise with respect to the levels of fertilizers and sources of fertilizers used. The yield obtained in terms of cut flowers of carnation as a result of the effects of those variables formed the major factor in determining the costs of cultivation. Considering the cost of cultivation and the gross returns, profit in terms of net returns and benefit: cost ratio were worked out for area of a $100m^2$.

## Result and Discussion

The data in respect of number of laterals, days required for fifty per cent flowering, flower yield of carnation per kg of fertilizers and vase life are presented in table 1. Among the sources, $S_1$ produced maximum number of laterals per plant followed by $S_2$, while $S_3$ produced minimum laterals per plant. Levels of K fertilizers did not differ significantly with respect to number of laterals produced per plant. The interaction effects were significant only at 180 DAP. The treatment combination ($S_1L_3$) produced maximum number of laterals per plant at 180 DAP. This indicated that optimum dose KCl fertilizer was optimal for producing higher number of laterals per plant. The results were in conformity with those of Mahesh [8], Satisha [9], Boztok., *et al*. [10] and Shahakar., *et al*. [1] who reported increases in number of laterals of carnation plant on increase in level of K fertilizers applied.

The days taken for 50% of the carnation plants to flower significantly differed due to sources of K fertilizers. Among the sources $S_2$ showed significantly less number of days for 50% flowering compared to $S_3$ treatment but was at par with $S_1$. Non-significant results were obtained with levels and interactions of treatment combinations. While days taken for first flower appearance, flower development fifty per cent flowering were all delayed by the application of higher level of K fertilizers, reduced level of K fertilizers resulted in earliness of all. Higher the level of K fertilizers, better the vegetative growth and hence the delay. $S_3$ resulted in delayed flower appearance whereas $S_2$ resulted in early flower appearance. Delayed flower appearance, when $S_3$ was applied, could be due to high availability of nitrogen in contrast to $S_2$ the vegetative growth period was less and sulphur availability enhanced the appearance of flower as fast as other source of K fertilizers. Similar conclusions reported by Sparnaaij., *et al*. [11] and Bhautkar [12] who reported that the first flower appearance is longest in carnation.

| Particulars | Laterals (no) | 50% flowering (Days) | (No. of cut flowers/sq. m.)/ kg fertilizer | Vase life (days) |
|---|---|---|---|---|
| Sources | 180 DAP | | | 210DAP |
| $S_1$ (KCl) | 5.89 | 198.2 | 166 | 5.99 |
| $S_2$ ($K_2SO_4$) | 4.77 | 196.1 | 187 | 6.44 |
| $S_3$ ($KNO_3$) | 4.25 | 202.9 | 162 | 5.75 |
| S. E. ± | 0.10 | 1.45 | 3.3 | 0.01 |
| C.D. at 5% | 0.29 | 4.25 | 9.7 | 0.04 |
| Levels | | | | |
| $L_1$ (75*, 225**) | 4.91 | 200.4 | 171.6 | 6.08 |
| $L_2$ (100*, 250**) | 5.03 | 200.4 | 172.8 | 6.09 |
| $L_3$ (125*, 275**) | 5.11 | 198.5 | 169.0 | 6.07 |
| $L_4$ (150*, 300**) | 4.82 | 197.1 | 173.0 | 6.00 |
| S. E. ± | 0.12 | 1.67 | 3.8 | 0.02 |
| C.D. at 5% | NS | NS | NS | 0.05 |
| Interactions | | | | |
| $S_1L_1$ | 5.60 | 196.5 | 157.7 | 6.21 |
| $S_1L_2$ | 5.80 | 200.1 | 177.8 | 5.84 |
| $S_1L_3$ | 6.30 | 202.2 | 159.2 | 6.13 |
| $S_1L_4$ | 5.86 | 193.9 | 169.3 | 5.76 |
| $S_2L_1$ | 4.53 | 200.3 | 178.2 | 6.37 |
| $S_2L_2$ | 4.80 | 196.9 | 199.1 | 6.59 |
| $S_2L_3$ | 4.83 | 196.6 | 191.0 | 6.34 |
| $S_2L_4$ | 4.90 | 191.6 | 179.2 | 6.46 |
| $S_3L_1$ | 4.60 | 204.3 | 158.1 | 5.66 |
| $S_3L_2$ | 4.50 | 205.2 | 162.9 | 5.85 |
| $S_3L_3$ | 4.20 | 196.5 | 156.7 | 5.73 |
| $S_3L_4$ | 3.70 | 205.6 | 169.9 | 5.77 |
| S. E. ± | 0.20 | 2.90 | 6.6 | 0.03 |
| C.D.at 5% | 0.59 | NS | NS | 0.08 |

**Table 1:** Carnation growth, yield and quality parameters as influenced by K fertilizers sources and levels.

*: Vegetative stage (mg $K_2O$/plant/2 days interval)

**: Flowering stage (mg $K_2O$/plant/2 days interval)

Flower yield per kg of fertilizers applied differed significantly between sources of K fertilizers. Among the sources $S_2$ produced significantly higher numbers compared to other sources of K fertilizers. The levels of K fertilizers and interactions between sources and levels of K fertilizers did not affect the flower yield. Application $S_2$ fertilizers resulted in higher ratio between flower yield and fertilizers applied. Higher efficiency associated with water solubility could be attributed to their maximum solubility property and quicker availability of nutrients as they get as dissociated faster in the solvent and reduce losses under levels of K fertilizers. The similar results in case of flower yield had been obtained by Mynett., *et al*. [13], Satish [9], Sawwan [14] and Krishna., *et al*. [15] who reported that the number of flowers per square meter in carnation with different varieties and fertigation levels.

Significant differences with respect to vase life of cut flowers of carnation were obtained between sources at 210 DAP. Among the sources, use of $S_2$ resulted in significantly longer vase life than with $S_1$ and $S_3$. Vase life of cut flowers differed significantly due to the levels of K fertilizers at 210 DAP. Among the levels significantly longer vase life produced by level $L_2$ as compared to $L_4$. At 210 DAP $L_2$ was at par with $L_1$ and $L_3$. Minimum vase life was due to L4 level. Interactions between sources and levels of K fertilizers with respect to vase life of cut flowers differed significantly at 210 DAP. The $S_2L_2$ treatment combination was superior to all other treatments combinations. Optimum amount of inorganic salts like $K_2SO_4$, KCl, $NH_4$ and $KNO_3$ delayed senescence by maintaining the osmotic potential in petal tissues and substituted metabolic sugars in extending vase life of carnation. Influence of water soluble $K_2SO_4$

| Sr. No. | Particulars | Total cost (Rs.) | | | | | | Depreciated cost of fixed costs (Rs.) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Fixed costs | | | | | | | | | | | | |
| A | Structure excluding cladding material @ Rs 300 $m^{-2}$ for the life span of 10 years | 30000 | | | | | | 750 | | | | | |
| B | Cladding material + shade net @ 50 $m^{-2}$ for (100 $m^{-2}$) for span of life 3 years | 5000 | | | | | | 834 | | | | | |
| C | Irrigation system (Drip)@ Rs. 60 $m^{-2}$ for the life span of 10 years | 3000 | | | | | | 175 | | | | | |
| D | Planting material @ Rs. 11/rooted cutting (24 rooted cuttings $m^{-2}$) for 100 square meter area | 26400 | | | | | | 6600 | | | | | |
| E | Frame work for training @ Rs. 27.50 $m^{-2}$ for life span of 2 years | 2750 | | | | | | 687 | | | | | |
| 2 | Repair and maintenance per annum | - | | | | | | 250 | | | | | |
| 3 | Interest on fixed cost | - | | | | | | 3932 | | | | | |
| 4 | Total operational cost * | - | | | | | | 13228 | | | | | |
| **Sr. No.** | **Particulars** | **$T_1$** | **$T_2$** | **$T_3$** | **$T_4$** | **$T_5$** | **$T_6$** | **$T_7$** | **$T_8$** | **$T_9$** | **$T_{10}$** | **$T_{11}$** | **$T_{12}$** |
| 5 | Cost of cultivation Rs. 150/ $m^2$ / 6 months** | 8213 | 8278 | 8394 | 8528 | 7850 | 7968 | 8048 | 8140 | 7661 | 7714 | 7768 | 7846 |
| 6 | Total cost of cultivation (4+5) Rs. | 21441 | 21522 | 21622 | 21756 | 21078 | 21196 | 21276 | 21368 | 20889 | 20942 | 20996 | 21079 |
| 7 | Revenue @ Rs 4/ cut flower | 58464 | 57600 | 62400 | 63168 | 63168 | 76128 | 74400 | 68832 | 51648 | 43008 | 61248 | 55872 |
| 8 | Net profit Rs. (7-6)/2 | 18512 | 18034 | 20389 | 20706 | 21045 | 27466 | 26562 | 23732 | 15380 | 11033 | 20126 | 17397 |
| 9 | Benefit : Cost ratio [8/(6/2)] | 1.73 | 1.68 | 1.89 | 1.90 | 2.00 | 2.59 | 2.50 | 2.22 | 1.47 | 1.05 | 1.92 | 1.65 |

**Table 2:** Economics of carnation cultivation as influenced by sources and levels of K fertilizers (100 $m^{-2}$ per 6 months)

*: $\dfrac{(a+c)\ 0.18}{\text{No. of years}} + \dfrac{(b)\ 0.18}{\text{No. of years}} + \dfrac{(d)\ 0.18}{\text{No. of years}} + \dfrac{(e)\ 0.18}{\text{No. of years}}$

***: All depreciated costs (a+b+c+d+e+2+3)* in obtaining significantly longer vase life might be due to higher fertilizer use efficiency associated with sulphate and higher absorption of water through the stem of cut flowers of carnation could reduce water loss and increase the shelf life. Mayak., *et al*. [16], who reported that the similar results did not affect the vase life of carnation cutflower

Among different treatment combinations, $T_6$ ($S_2L_2$) recorded their maximum revenue, net profit and benefit: cost ratio. The profit depends not only on the productivity of the crop but also the quality of the produce in association with the competitive price in the market. This can be achieved by lowering the cost of production, simultaneously. In a way this in-turn is possible with the optimization of nutrients, efficient mode and form of application. Optimum level of $K_2SO_4$ fertilizer dose provided through fertigation could be considered as a probable reason for obtaining the above results. Similar conclusions on findings with fertilizers were observed by Zouari [17], Rejman and Mynett [18] and Jagannath and Gopinath [19] who reported that application of proper fertilizers increased the benefit: cost ratio in carnation under protected condition.

## Conclusion

It may be concluded that considering the growth, yield and quality of flowers use of $K_2SO_4$ at the rate of 100 mg $K_2O$ per plant during vegetative growth and 250 mg $K_2O$ per plant after flowering was the most suitable for growing carnation under polyhouse conditions. The results are based on study for first 7 months of the plant growth. The study needs to be continued for further 2 years to explore full potential of the carnation plant under polyhouse conditions.

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