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***Research Paper***

# Influence of graded levels of nitrogen and potassium on physiological growth parameters and flower yield of garland chrysanthemum (*Chrysanthemum coronarium* L.)

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**Abstract :** An investigation was carried out at Horticultural College and Research Institute, Venkataramannagudem, West Godavari district of Andhra Pradesh during the year 2015-16 to evaluate the influence of graded levels of nitrogen and potassium on physiological growth parameters and flower yield of garland chrysanthemum. The study has revealed that significantly highest number of leaves per plant (98.00), leaf area per plant (988.00 $cm^2$), LAI (0.618), LAD (268.04), CGR, AGR, RGR, NAR, Chlorophyll-a, b and total chlorophyll content were observed by application of nitrogen at the rate of 200 kg $ha^{-1}$ in combination with potassium at the rate of 150 kg $ha^{-1}$ along with phosphorus as a common dose to all the treatments at the rate of 100 kg $ha^{-1}$ during *Rabi* season. Significantly highest number of flowers per plant (28.00), flower yield per plant (36.00 g) and flower yield per hectare (25.25q) were observed by application of nitrogen at the rate of 200 kg $ha^{-1}$ in combination with potassium at the rate of 150 kg $ha^{-1}$.

**Key Words :** Garland chrysanthemum, Nitrogen, Potassium, LAI, LAD, AGR, CGR, RGR, NAR, Flower yield

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## Introduction

Garland chrysanthemum (*Chrysanthemum coronarium* L.) is considered to be native of Mediterranean region and distributed throughout Europe, northern Africa and Asia (FAO, 2007). The *Chrysanthemum coronarium* L. var. 'Coronarium' is generally called as garland chrysanthemum, whereas, *Chrysanthemum coronarium* Bailey var. 'Spatiosum' is referred to as crown daisy (Anonymous, 2000). It is commonly called as 'Tong Hao' in China, 'Shungiku' in Japan and 'Ssukgat' in Korea. In India, the annual

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chrysanthemum has been naturalized, cultivated and locally called with different vernacular names *viz.*,'Bijli' in Nagpur (Meshram *et al.*, 2008), 'Baboona' in Haryana (Mishra *et al.*, 2002) 'Guldhak' in Punjab, 'Market' in Delhi and 'Gendi' in Uttar Pradesh (Arora, 1990). It is a winter season annual and propagated by seeds. It produces white and yellow coloured blooms and generally used in garland making as well as bedding material in the landscape gardens. The flowers are generally used for making garlands, veni and also used in the floral decorations during social and religious functions. Garland chrysanthemum is different from the regular chrysanthemum in many aspects. The crop has relatively short duration and photo-insensitive. Under moderate climatic conditions flowering is observed almost throughout the year. The plant is considered to be hardier, vigorous and grows taller. Application of major nutrients *viz.*, nitrogen, phosphorus and potassium play an important role in growth and development of many flower crops there by increased the flower yield. Based on the available literature, it is evident that very little research work was carried out earlier on vegetative and floral responses of garland chrysanthemum to different levels of nitrogen, phosphorus and potassium in many parts of the country especially in the coastal regions. Keeping all these things in view, the present investigation has been planned to study the influence of different levels of nitrogen and potassium on the physiological growth responses and flower yield of garland chrysanthemum.

## MATERIAL AND METHODS

The present investigation was carried out at Horticultural College and Research Institute, Venkataramannagudem, West Godavari district of Andhra Pradesh during the year 2015-2016. The experimental area had a medium red soil and sandy loam in texture with a pH of 6.57 and moderate in fertility. Altogether, there were 16 treatments consisting of 4 levels each of nitrogen *viz.*, $N_1$ (50 kg ha$^{-1}$), $N_2$ (100 kg ha$^{-1}$), $N_3$ (150 kg ha$^{-1}$), $N_4$ (200 kg ha$^{-1}$) and potassium $K_1$(50 kg ha$^{-1}$), $K_2$ (100 kg ha$^{-1}$), $K_3$ (150 kg ha$^{-1}$), $K_4$ (200 kg ha$^{-1}$) with a single dose of phosphorus (100 kg ha$^{-1}$) application to all the treatments. The experiment was laid out in a Factorial Randomized Block Design with three replications. The gross plot size was 2.5 x 2.5 m$^2$ and the net plot size was 2.25 x 2.25 m$^2$. Spacing adopted was 40 cm between the rows and plants within a row. Straight fertilizers *viz*., urea, single super phosphate and muriate of potash were taken as the sources of N, $P_2O_5$ and $K_2O$, respectively. Entire dose of phosphorus was applied as a basal dose and graded doses of nitrogen and potassium were applied in two split doses at 30 and 60 days after planting as per the treatments fixed. Physiological growth and yield parameters *viz.*, number of leaves per plant, leaf area per plant, leaf area index (Sestak *et al.*, 1971), leaf area duration, crop growth rate (Watson, 1952), absolute growth rate, relative growth rate, net assimilation rate (Gregory, 1926), chlorophyll content (Arnon, 1949), number of flowers per plant, flower yield per plant and flower yield per hectare were recorded as per the standard procedures outlined by different scientists. The data collected on each character were subjected to statistical analysis by ANOVA technique as per the basic technique described by Panse and Sukhatme (1967). The treatment means were compared using the least significant difference values calculated at 5 per cent level of significance.

## RESULTS AND DISCUSSION

The data pertaining to number of leaves per plant in garland chrysanthemum are presented in Table 1.The data were found significant with respect to the individual and interaction effects of nitrogen and potassium on number of leaves per plant. Among the nitrogen levels, application of nitrogen at the rate of 50 kg ha$^{-1}$ recorded significantly lowest number of leaves per plant (62.27), whereas, significantly highest number of leaves per plant (92.02) was observed by application of nitrogen at the rate of 200 kg ha$^{-1}$. Significant differences were observed with respect to number of leaves per plant by application of graded levels of potassium. Application of potassium at the rate of 50 kg ha$^{-1}$ recorded significantly lowest number of leaves per plant (74.69), whereas, significantly highest number of leaves per plant (81.41) was recorded by application of potassium at the rate of 150 kg ha$^{-1}$ and was found at par with the application of potassium at the rate of 200 kg ha$^{-1}$. Significant differences were observed in the interaction effect of nitrogen and potassium with respect to number of leaves per plant. Significantly lowest number of leaves per plant (53.25) was registered by application of nitrogen and potassium each at the rate of 50 kg ha$^{-1}$, whereas, significantly highest number of leaves per plant (98.00) was recorded by application of nitrogen and potassium, respectively at the rate of 200 and 150 kg ha$^{-1}$. Based on the results obtained it may be concluded that there were significant differences in the number of leaves per plant by application of graded levels of nitrogen and potassium. Vegetative growth in garland chrysanthemum concerned with number of leaves per plant increased by application of increased quantity of nitrogen. The reason may be attributed to increased biosynthesis of nucleic acids which in turn promoted the plant growth as nitrogen is an essential part of nucleic acids. Number of leaves per plant was found increased by application of graded levels of potassium. The reason might be due to an increase in the rate of photosynthetic activity and translocation of photo-assimilates to the growing meristematic and cambial tissue thereby increasing the number of leaves per plant due to cell differentiation. The present result was found in agreement with the earlier findings of Singh and Baboo (2003) in chrysanthemum. Shah *et al.* (2014) reported that an increase in the level of application of potassium produced increased number of leaves in *Zinnia elegans*. Application of higher doses of nitrogen and potassium increased the plant height and number of branches per plant thereby increased the vegetative buds and ultimately increased the number of leaves. Application of higher quantity of nitrogen showed the ability to increase cell division and cell differentiation in the growing meristematic tissue which increased the overall leaf production. The present results are in close confirmity with the earlier findings of Javid *et al*. (2005) who reported that application of NPK at the rate of 30:20:20 g $m^{-2}$ produced more number of leaves per plant in zinnia. Sharma *et al*. (2006) recorded maximum number of leaves (162.50) per plant by application of nitrogen at the rate of 200 kg $ha^{-1}$ in African marigold. Similar kind of result was reported earlier by Singh *et al*. (2008) and Sajid and Amin (2014) in chrysanthemum.

The data pertaining to leaf area per plant in garland chrysanthemum was presented in Table 1. Application of nitrogen at the rate of 50 kg $ha^{-1}$ recorded significantly lowest leaf area per plant (691.35 $cm^2$), whereas, significantly highest leaf area per plant (936.50 $cm^2$) was observed by application of nitrogen at the rate of 200 kg $ha^{-1}$. Application of potassium at the rate of 50 kg $ha^{-1}$ recorded significantly lowest leaf area per plant (774.18 $cm^2$), whereas, significantly highest leaf area per plant (853.90 $cm^2$) was recorded by application of potassium at the rate of 150 kg $ha^{-1}$ and was found at par by application of potassium at the rate of 200 kg $ha^{-1}$. Significant differences were observed in the interaction effects of nitrogen and potassium with respect to leaf area per plant. Significantly lowest leaf area per plant (603.70 $cm^2$) was recorded by application of nitrogen and potassium each at the rate of 50 kg $ha^{-1}$, whereas, significantly highest leaf area per plant (988.00 $cm^2$) was recorded with nitrogen and potassium applied at the rate of 200 and 150 kg $ha^{-1}$, respectively. Based on the results obtained it may be concluded that nitrogen is considered to be the elementary constituent of many amino acids, nucleic acids, proteins, nucleotides, enzymes, chlorophyll and numerous secondary metabolites such as alkaloids hence, treated as an important constituent of protoplasm. Nitrogen helped in increasing the vegetative growth by increasing the cell division and cell elongation (Meyer *et al*., 1973). An increase in the photosynthetic activity and translocation of photo-assimilates to the site of growth are used predominantly in the synthesis of nucleic acids and proteins hence, application of nitrogen and potassium fertilizers during growth stage increased the vegetative growth thereby increased leaf area was observed in annual chrysanthemum (Mengel and Kirby, 1982).

**Table 1: Effect of different levels of nitrogen and potassium on number of leaves per plant, leaf area per plant, leaf area index per plant in garland chrysanthemum**

| Treatments | Number of leaves per plant | | | | | Leaf area per plant ($cm^2$) | | | | | Leaf area index (LAI) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 90 DAT | | | | | 90 DAT | | | | | 90 DAT | | | | |
| | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean |
| $N_{50}$ | 53.25 | 61.33 | 65.81 | 68.67 | 62.27 | 603.70 | 713.00 | 727.68 | 721.00 | 691.35 | 0.377 | 0.446 | 0.455 | 0.457 | 0.432 |
| $N_{100}$ | 75.33 | 76.40 | 77.99 | 78.93 | 77.16 | 738.00 | 790.00 | 814.93 | 800.00 | 785.73 | 0.461 | 0.494 | 0.500 | 0.509 | 0.491 |
| $N_{150}$ | 81.60 | 82.07 | 83.83 | 83.53 | 82.76 | 855.00 | 869.00 | 885.00 | 893.00 | 875.50 | 0.534 | 0.543 | 0.553 | 0.558 | 0.547 |
| $N_{200}$ | 88.57 | 89.50 | 98.00 | 92.00 | 92.02 | 900.00 | 924.00 | 988.00 | 934.00 | 936.50 | 0.563 | 0.578 | 0.618 | 0.584 | 0.585 |
| Mean | 74.69 | 77.33 | 81.41 | 80.78 | 78.55 | 774.18 | 824.00 | 853.90 | 837.00 | 822.27 | 0.484 | 0.515 | 0.534 | 0.523 | 0.514 |
| | S.E.± | | C.D. (P=0.05) | | | S.E.± | | C.D. (P=0.05) | | | S.E.± | | C.D. (P=0.05) | | |
| N | 1.12 | | 3.29 | | | 9.73 | | 28.28 | | | 0.008 | | 0.023 | | |
| K | 1.12 | | 3.29 | | | 9.73 | | 28.28 | | | 0.008 | | 0.023 | | |
| N × K | 2.36 | | 6.15 | | | 18.48 | | 53.73 | | | 0.015 | | 0.044 | | |

Nitrogen is implicated in many of the enzyme reactions taking place in the cells and thus, plays an active role in energy metabolism. Thus, application of higher dose of nitrogen improved the cell division and differentiation which led to greater plant height, number of branches per plant and leaf area. The present result is in confirmity with the earlier findings of Joshi *et al*. (2013) and Sajid and Amin (2014) in chrysanthemum. Maintenance of higher turgor potential in the cell leads to cell expansion thereby increased the leaf size and ultimately the leaf area per plant by application of higher dose of potassium. The present result is in agreement with the earlier findings of Shah *et al*. (2014) who reported an increase in leaf area with an increase in the level of potassium application in *Zinnia elegans*.

Significant differences were observed in the data pertaining to leaf area index (LAI) by application of nitrogen and potassium (Table 1) in garland chrysanthemum. Application of nitrogen at the rate of 50 kg $ha^{-1}$ recorded significantly lowest leaf area index (0.432), whereas, significantly highest leaf area index (0.585) was observed by application of nitrogen at the rate of 200 kg $ha^{-1}$. Application of potassium at the rate of 50 kg $ha^{-1}$ recorded significantly lowest leaf area index (0.484), whereas, significantly highest leaf area index (0.534) was recorded by application of potassium at the rate of 150 kg $ha^{-1}$. Significant differences were observed in the interaction effects of nitrogen and potassium with respect to leaf area index. Significantly lowest leaf area index (0.377) was observed by application of nitrogen and potassium each at the rate of 50 kg $ha^{-1}$, whereas, significantly highest leaf area index (0.618) was observed by application of nitrogen and potassium each at the rate of 200 and 150 kg $ha^{-1}$, respectively. Based on the results obtained it may be concluded that leaf area index was found increased by an increase in the level of application of nitrogen and potassium which ultimately helped in the structural development of the plant there by improved the number of leaves and leaf area per plant which in turn regulated higher leaf area index. The present result was found in tune to the earlier findings of Ramachandra (1982) and Mantur (1988) in China aster who reported an increase in the LAI by increasing the dose of NPK.

The data pertaining to leaf area duration (LAD) was found significant with respect to the application of nitrogen and potassium in garland chrysanthemum (Table 2). Application of nitrogen at the rate of 50 kg $ha^{-1}$ recorded significantly lowest leaf area duration (181.81), whereas, significantly highest leaf area duration (254.27) was observed by application of nitrogen at the rate of 200 kg $ha^{1}$. Application of potassium at the rate of 50 kg $ha^{-1}$ recorded significantly lowest leaf area duration (207.45), whereas, significantly highest leaf area duration (228.43) was observed by application of potassium at the rate of 150 kg $ha^{-1}$. Significantly lowest leaf area duration (161.48) was observed by application of nitrogen and potassium each at the rate of 50 kg $ha^{-1}$, whereas, significantly highest leaf area duration (268.04) was observed by application of nitrogen and potassium at the rate of 200 and 150 kg $ha^{-1}$, respectively. Leaf area duration is not only important to have a reasonable green cover per unit of ground area, but also important in recording the increased yield. In the present investigation, high LAI value coupled with LAD in greater range signifies maintenance of more number of green leaves for a longer period of time. The LAD was found more in plants applied with 200 and 150 kg $ha^{-1}$ of nitrogen and potassium, respectively.

**Table 2: Effect of different levels of nitrogen and potassium on leaf area duration and crop growth rate in garland chrysanthemum**

| Treatments | Leaf area duration ($dm^2 d^{-1}$) | | | | | Crop growth rate ($g\ m^{-2} d^{-1}$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 60-90 DAT | | | | | 30-60 DAT | | | | | 60-90 DAT | | | | |
| | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean |
| $N_{50}$ | 161.48 | 181.16 | 192.50 | 191.89 | 181.81 | 1.26 | 1.27 | 1.28 | 1.30 | 1.28 | 0.42 | 0.46 | 0.63 | 0.54 | 0.51 |
| $N_{100}$ | 206.28 | 211.45 | 214.00 | 212.54 | 211.08 | 1.28 | 1.22 | 1.48 | 1.50 | 1.37 | 0.52 | 0.53 | 0.61 | 0.53 | 0.55 |
| $N_{150}$ | 222.07 | 223.99 | 238.93 | 229.37 | 228.71 | 1.50 | 1.56 | 1.56 | 1.56 | 1.55 | 0.58 | 0.56 | 0.56 | 0.56 | 0.57 |
| $N_{200}$ | 239.84 | 250.73 | 268.04 | 258.40 | 254.27 | 1.56 | 1.56 | 1.94 | 1.64 | 1.67 | 0.62 | 0.64 | 0.70 | 0.66 | 0.66 |
| Mean | 207.45 | 216.95 | 228.43 | 223.09 | 219.01 | 1.40 | 1.40 | 1.55 | 1.50 | 1.73 | 0.53 | 0.56 | 0.63 | 0.57 | 0.57 |
| | | S.E.± | | C.D. (P=0.05) | | | S.E.± | | C.D. (P=0.05) | | | S.E.± | | C.D. (P=0.05) | |
| N | | 2.77 | | 8.05 | | | 0.01 | | 0.03 | | | 0.01 | | 0.02 | |
| K | | 2.77 | | 8.05 | | | 0.01 | | 0.03 | | | 0.01 | | 0.02 | |
| N × K | | 5.26 | | 15.30 | | | 0.03 | | 0.09 | | | 0.02 | | 0.04 | |

The data pertaining to crop growth rate (CGR) with the application of nitrogen and potassium was found significant in garland chrysanthemum (Table 2). Application of nitrogen at the rate of 50 kg ha$^{-1}$ recorded significantly lowest crop growth rate (1.28 and 0.51, respectively at 60 and 90 DAT), whereas, significantly highest crop growth rate (1.67 and 0.66g m$^{-2}$ d$^{-1}$, respectively at 60 and 90 DAT) was observed by application of nitrogen at the rate of 200 kg ha$^{1}$. Application of potassium at the rate of 50 kg ha$^{-1}$ recorded significantly lowest crop growth rate (1.40 and 0.53 g m$^{-2}$ d$^{-1}$, respectively at 60 and 90 DAT), whereas, significantly highest crop growth rate (1.55 and 0.63g m$^{-2}$ d$^{-1}$, respectively at 60 and 90 DAT) was recorded by application of potassium at the rate of 200 kg ha$^{-1}$ which was at par with the application potassium at the rate of 150 kg ha$^{-1}$. Significant differences were observed in the interaction effects of nitrogen and potassium with respect to crop growth rate at different days of observation recorded. Significantly lowest crop growth rate (1.26 and 0.42 g m$^{-2}$ d$^{-1}$, respectively at 60 and 90 DAT) was observed with the application of nitrogen and potassium each at the rate of 50 kg ha$^{-1}$, whereas, significantly highest crop growth rate (1.94 and 0.70g m$^{-2}$ d$^{-1}$, respectively at 60 and 90 DAT) was observed with the application of nitrogen and potassium, respectively at the rate of 200 and 150 kg ha$^{-1}$. Based on the results obtained, it may be concluded that an increase in the level of nitrogen and potassium application gradually increased the crop growth rate upto 60 days after transplanting and then onwards a gradual decrease was observed till the end of the crop removal. It could be due to a decrease in the vigour of vegetative growth by diversion of nutrients to the development of floral parts. Leaves and branches were found turned into yellow colour by diverting the reserved food material towards the reproductive structures there by the CGR was found decreased in comparison to the CGR recorded at 60 DAT indicating an increase in the dry matter production per unit area per unit time during the peak growth period of the crop. The present result is in close confirmity with the earlier finding reported by Dorajeerao (2010) in garland chrysanthemum.

Data pertaining to absolute growth rate (AGR) by application of nitrogen and potassium in garland chrysanthemum was found significant (Table 3). Application of nitrogen at the rate of 50 kg ha$^{-1}$ recorded significantly lowest absolute growth rate (1.05 and 0.13 cm d$^{-1}$, respectively at 60 and 90 DAT), whereas, significantly highest absolute growth rate (1.79 and 0.76 cm d$^{-1}$, respectively at 60 and 90 DAT) was observed by application of nitrogen at the rate of 200 kg ha$^{1}$. Application of potassium at the rate of 50 kg ha$^{-1}$ recorded significantly lowest absolute growth rate (1.27 and 0.34 cm d$^{-1}$, respectively at 60 and 90 DAT), whereas, significantly highest absolute growth rate (1.52 and 0.51 cm d$^{-1}$, respectively at 60 and 90 DAT) was recorded by application of potassium at the rate of 150 kg ha$^{-1}$. Significantly lowest absolute growth rate (0.83 and 0.07 cm d$^{-1}$, respectively at 60 and 90 DAT) was observed by application of nitrogen and potassium each at the rate of 50 kg ha$^{-1}$, whereas, significantly highest absolute growth rate (2.14 and 1.02 cm d$^{-1}$, respectively at 60 and 90 DAT) was observed by application of nitrogen and potassium at the rate of 200 and 150 kg ha$^{-1}$, respectively. Based on the results obtained it may be concluded that an increase in absolute growth rate was observed due to an increase in the level of nitrogen and potassium applied.

**Table 3: Effect of different levels of nitrogen and potassium on absolute growth rate in garland chrysanthemum**

| Treatments | Absolute growth rate (cm d$^{-1}$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 30-60 DAT | | | | | 60-90 DAT | | | | |
| | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean |
| $N_{50}$ | 0.83 | 0.97 | 1.15 | 1.26 | 1.05 | 0.07 | 0.10 | 0.17 | 0.20 | 0.13 |
| $N_{100}$ | 1.27 | 1.31 | 1.33 | 1.38 | 1.32 | 0.24 | 0.27 | 0.35 | 0.40 | 0.32 |
| $N_{150}$ | 1.42 | 1.44 | 1.45 | 1.48 | 1.45 | 0.47 | 0.48 | 0.50 | 0.53 | 0.49 |
| $N_{200}$ | 1.57 | 1.64 | 2.14 | 1.79 | 1.79 | 0.59 | 0.64 | 1.02 | 0.79 | 0.76 |
| Mean | 1.27 | 1.34 | 1.52 | 1.48 | 1.40 | 0.34 | 0.37 | 0.51 | 0.48 | 0.43 |
| | S.E.± | | C.D. (P=0.05) | | | S.E.± | | C.D. (P=0.05) | | |
| N | 0.03 | | 0.10 | | | 0.02 | | 0.06 | | |
| K | 0.03 | | 0.10 | | | 0.02 | | 0.06 | | |
| N × K | 0.07 | | 0.20 | | | 0.04 | | 0.13 | | |

The absolute growth rate was found increased upto 60 DAT and there after a gradual decrease was observed due to diversion of photo-assimilates towards reproductive phase thereby a decrease was noticed in terms of vegetative growth.

The data pertaining to relative growth rate (RGR) by application of nitrogen and potassium in garland chrysanthemum are presented in Table 4. Application of nitrogen at the rate of 50 kg $ha^{-1}$ recorded significantly lowest relative growth rate (0.058 and 0.029 g $g^{-1}$ $d^{-1}$, respectively at 60 and 90 DAT), whereas, significantly highest relative growth rate (0.069 and 0.036 g $g^{-1}$ $d^{-1}$, respectively at 60 and 90 DAT) was observed by application of nitrogen at the rate of 200 kg $ha^{-1}$. Application of potassium at the rate of 50 kg $ha^{-1}$ recorded significantly lowest relative growth rate (0.061 and 0.030 g $g^{-1}$ $d^{-1}$, respectively at 60 and 90 DAT), whereas, significantly highest relative growth rate (0.066 and 0.037 g $g^{-1}$ $d^{-1}$, respectively at 60 and 90 DAT) was recorded by application of potassium at the rate of 150 kg $ha^{-1}$ which was found at par with the application potassium at the rate of 200 kg $ha^{-1}$. Significantly lowest relative growth rate (0.052 and 0.023g $g^{-1}$ $d^{-1}$, respectively at 60 and 90 DAT) was observed by application of nitrogen and potassium each at the rate of 50 kg $ha^{-1}$, whereas, significantly highest relative growth rate (0.074 and 0.037 g $g^{-1}$ $d^{-1}$, respectively at 60 and 90 DAT) was observed by application of nitrogen and potassium at the rate of 200 and 150 kg $ha^{-1}$, respectively. Based on the results obtained it may be concluded that an increase in relative growth rate was observed by application of graded levels of nitrogen and potassium. The relative growth rate showed an increasing trend upto 60 days after transplanting and there after showed a decreasing trend which might be due to a decrease in the dry matter accumulation and diversion of photo-assimilates towards structural development. With the passage of time, plant dry weight was found increased by translocation of photo-assimilates towards the reproductive organs and thereafter a decrease was observed in the photosynthetic activity of the matured leaves due to senescence and mutual shading effect which led to a decrease in the per day dry weight increment in plants. The present result is in close confirmity with the earlier finding of Satar *et al.* (2012) in annual chrysanthemum and Sanghamitra (2015) in marigold.

Significant differences were observed in the data pertaining to net assimilation rate (NAR) by application of nitrogen and potassium in garland chrysanthemum (Table 5). Application of nitrogen at the rate of 50 kg $ha^{-1}$ recorded significantly lowest net assimilation rate (4.39 and 3.16 g $cm^{-2}$ $d^{-1}$, respectively at 60 and 90 DAT), whereas, significantly highest net assimilation rate (4.95 and 4.12 g $cm^{-2}$ $d^{-1}$, respectively at 60 and 90 DAT) was observed by application of nitrogen at the rate of 200 kg $ha^{1}$. Application of potassium at the rate of 50 kg $ha^{-1}$ recorded significantly lowest net assimilation rate (4.35 and 3.21 g $cm^{-2}$ $d^{-1}$, respectively at 60 and 90 DAT), whereas, significantly highest net assimilation rate (4.83 and 4.02 g $cm^{-2}$ $d^{-1}$, respectively at 60 and 90 DAT) was recorded by application of potassium at the rate of 150 kg $ha^{-1}$. Significantly lowest net assimilation rate (4.04 and 2.61 g $cm^{-2}$ $d^{-1}$, respectively at 60 and 90 DAT) was observed by application of nitrogen and potassium each at the rate of 50 kg $ha^{-1}$, whereas, significantly highest net assimilation rate (5.55 and 4.40 g $cm^{-2}$ $d^{-1}$, respectively at 60 and 90 DAT) was observed by application of nitrogen and potassium at the rate of 200

**Table 4: Effect of different levels of nitrogen and potassium on relative growth rate in garland chrysanthemum**

| Treatments | Relative growth rate (g $g^{-1}$ $d^{-1}$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 30-60 DAT | | | | | 60-90 DAT | | | | |
| | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean |
| $N_{50}$ | 0.052 | 0.060 | 0.059 | 0.061 | 0.058 | 0.023 | 0.025 | 0.034 | 0.033 | 0.029 |
| $N_{100}$ | 0.060 | 0.059 | 0.065 | 0.066 | 0.063 | 0.031 | 0.030 | 0.035 | 0.034 | 0.033 |
| $N_{150}$ | 0.066 | 0.067 | 0.067 | 0.067 | 0.067 | 0.034 | 0.033 | 0.033 | 0.033 | 0.033 |
| $N_{200}$ | 0.067 | 0.067 | 0.074 | 0.069 | 0.069 | 0.030 | 0.032 | 0.037 | 0.035 | 0.036 |
| Mean | 0.061 | 0.063 | 0.066 | 0.066 | 0.064 | 0.030 | 0.033 | 0.037 | 0.035 | 0.033 |
| | S.E.± | | C.D. (P=0.05) | | | S.E.± | | C.D. (P=0.05) | | |
| N | 0.01 | | 0.02 | | | 0.01 | | 0.02 | | |
| K | 0.01 | | 0.02 | | | 0.01 | | 0.02 | | |
| N × K | 0.02 | | 0.04 | | | 0.02 | | 0.03 | | |

and 150 kg ha$^{-1}$, respectively. Based on the results obtained it may be concluded that an increase in the application of graded levels of nitrogen and potassium significantly increased the net assimilation rate. Further, net assimilation rate was observed more upto 60 days after transplanting and there after decreased mainly due to ageing of the leaves and mutual shading effect of the plants with each other thereby a decrease was observed in the photosynthetic activity of leaves, hence, a decrease in the net assimilation rate was observed during the later phase of vegetative growth phase *i.e.*, 60 days after transplanting rather than to the earlier phase of plant growth where exposure of all the leaves completely to sunlight was observed. Further, a significant decrease in NAR was noticed with an increased level of potassium application over and above 150 kg ha$^{-1}$. The reason might be due to saturation capacity of the plant to the excess application of nutrient. The present result is in confirmity with the earlier result reported by Dorajeerao (2010) in garland chrysanthemum and Sanghamitra (2015) in marigold.

Significant differences were observed in the data pertaining to chlorophyll-a, b and total chlorophyll content by application of nitrogen and potassium in garland chrysanthemum (Table 6). Application of nitrogen at the rate of 50 kg ha$^{-1}$ recorded significantly lowest chlorophyll-a, b and total chlorophyll content, whereas, significantly highest chlorophyll-a, b and total chlorophyll content was observed by application of nitrogen at the rate of 200 kg ha$^{-1}$ on all the days of observation recorded. Application of potassium at the rate of 50 kg ha$^{-1}$ recorded significantly lowest chlorophyll-a, b and total chlorophyll content, whereas, significantly highest chlorophyll-a, b and total chlorophyll content was recorded by application of potassium at the rate of 150 kg ha$^{-1}$. Significantly lowest chlorophyll-a, b and total chlorophyll content was observed by application of nitrogen and potassium each at the rate of 50 kg ha$^{-1}$, whereas, significantly highest chlorophyll-a, b and total chlorophyll content was observed by application of

**Table 5: Effect of different levels of nitrogen and potassium on net assimilation rate in garland chrysanthemum**

| Treatments | Net assimilation rate (g cm$^{-2}$ d$^{-1}$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 30-60 DAT | | | | | 60-90 DAT | | | | |
| | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean |
| $N_{50}$ | 4.04 | 5.02 | 4.09 | 4.44 | 4.39 | 2.61 | 2.82 | 3.45 | 3.21 | 3.16 |
| $N_{100}$ | 4.36 | 4.01 | 5.02 | 5.21 | 4.65 | 4.33 | 3.68 | 3.66 | 3.46 | 3.60 |
| $N_{150}$ | 4.00 | 4.20 | 4.34 | 4.93 | 4.37 | 2.18 | 3.20 | 3.99 | 3.78 | 3.66 |
| $N_{200}$ | 5.00 | 4.50 | 5.55 | 4.73 | 4.95 | 3.11 | 3.71 | 4.40 | 4.25 | 4.12 |
| Mean | 4.35 | 4.43 | 4.83 | 4.76 | 4.59 | 3.21 | 3.53 | 4.02 | 3.83 | 3.79 |
| | S.E.± | | C.D. (P=0.05) | | | S.E.± | | C.D. (P=0.05) | | |
| N | 0.02 | | 0.07 | | | 0.03 | | 0.10 | | |
| K | 0.02 | | 0.07 | | | 0.03 | | 0.10 | | |
| N × K | 0.05 | | 0.14 | | | 0.06 | | 0.19 | | |

**Table 6: Effect of different levels of nitrogen and potassium on chlorophyll-a, b and total chlorophyll in garland chrysanthemum**

| Treatments | Chlorophyll-a | | | | | Chlorophyll-b | | | | | Total chlorophyll | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 90 DAT | | | | | 90 DAT | | | | | 90 DAT | | | | |
| | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean |
| $N_{50}$ | 0.02 | 0.05 | 0.07 | 0.09 | 0.06 | 0.03 | 0.12 | 0.14 | 0.14 | 0.09 | 0.09 | 0.10 | 0.11 | 0.13 | 0.14 |
| $N_{100}$ | 0.10 | 0.12 | 0.13 | 0.15 | 0.13 | 0.16 | 0.15 | 0.16 | 0.17 | 0.16 | 0.12 | 0.14 | 0.15 | 0.15 | 0.16 |
| $N_{150}$ | 0.16 | 0.21 | 0.24 | 0.27 | 0.22 | 0.17 | 0.20 | 0.20 | 0.20 | 0.19 | 0.17 | 0.17 | 0.16 | 0.19 | 0.19 |
| $N_{200}$ | 0.31 | 0.33 | 0.41 | 0.33 | 0.33 | 0.22 | 0.21 | 0.30 | 0.23 | 0.24 | 0.21 | 0.19 | 0.25 | 0.23 | 0.24 |
| Mean | 0.15 | 0.18 | 0.22 | 0.21 | 0.18 | 0.14 | 0.17 | 0.20 | 0.20 | 0.17 | 0.15 | 0.16 | 0.17 | 0.16 | 0.18 |
| | S.E.± | | C.D. (P=0.05) | | | S.E.± | | C.D. (P=0.05) | | | S.E.± | | C.D. (P=0.05) | | |
| N | 0.01 | | 0.03 | | | 0.01 | | 0.03 | | | 0.004 | | 0.012 | | |
| K | 0.01 | | 0.03 | | | 0.01 | | 0.03 | | | 0.004 | | 0.012 | | |
| N × K | 0.02 | | 0.04 | | | 0.02 | | 0.06 | | | 0.008 | | 0.024 | | |

nitrogen and potassium at the rate of 200 and 150 kg $ha^{-1}$, respectively. Based on the results obtained it may be concluded that an increase in the level of nitrogen and potassium increased the chlorophyll content in leaves at 30 DAT (data not presented), whereas, at a later phase of plant growth *i.e.,* 60 and 90 DAT the chlorophyll content decreased gradually due to the translocation of nutrients towards the reproductive growth in the plant thereby a decrease was observed in the chlorophyll content of leaves at 60 and 90 DAT. An increase in the chlorophyll content was observed with an increase in the level of application of nitrogen which might be due to a positive correlation exhibited by the formation of chlorophylls with the availability of nitrogen in the leaves, mainly due to the presence of nitrogen in the structure of chlorophyll molecule. Similar kind of result was observed by Sharma *et al*. (2006) in African marigold by application of nitrogen at the rate of 200 kg $ha^{-1}$. Potassium plays a key role in the synthesis of precursor required for the chlorophyll pigments. The higher chlorophyll content in leaves improved the conversion of radiation energy into primary chemical energy in the form of ATP and NADPH in the chloroplasts. Potassium generally promotes the synthesis of catalase and peroxidase enzymes which have the capability of scavenging the free radicals produced in the plant system thus improved the general health of plants. Similar kind of observation was reported earlier in banana by Kumar and Kumar (2008) which was found in close confirmation with the present result.

The data pertaining to number of flowers per plant in garland chrysanthemum are presented in Table 7. The data were found significant with respect to individual and interaction effects of nitrogen and potassium. Significantly lowest number of flowers per plant was recorded by application of nitrogen at the rate of 50 kg $ha^{-1}$ (10.40), whereas, application of nitrogen at the rate of 200 kg $ha^{-1}$ recorded significantly highest number of flowers per plant (22.13). Significantly lowest number of flowers per plant was recorded by application of potassium at the rate of 50 kg $ha^{-1}$ (12.77), whereas, application of potassium at the rate of 200 kg $ha^{-1}$ recorded significantly highest number of flowers per plant (17.46). Among the combination of doses, application of nitrogen and potassium each at the rate of 50 kg $ha^{-1}$ recorded significantly lowest number of flowers per plant (7.63), whereas, application of nitrogen and potassium each at the rate of 200 and 150 kg $ha^{-1}$, respectively recorded significantly highest number of flowers per plant (28.00). Based on the results obtained it could be concluded that application of higher levels of nitrogen and potassium nutrients might have enhanced the structural development as well as biochemical activities of the plant which helped in diversion of more food reserves towards the developing flower buds which resulted in more number of flowers per plant. Similar kind of result was noticed earlier by Sharma *et al*. (2006) with an increased dose of nitrogen application at the rate of 200 kg $ha^{-1}$ in African marigold.

The data pertaining to flower yield per plant and per hectare are presented in Table 7. The data were found significant with respect to the individual and interaction effects of nitrogen and potassium. Significantly highest flower yield per plant and per hectare was observed by application of nitrogen at the rate of 200 kg $ha^{-1}$ (25.38 g and 18.38 q, respectively), whereas, significantly lowest flower yield per plant as well as per hectare was observed by application of nitrogen at the

**Table 7: Effect of different levels of nitrogen and potassium on number of flowers per plant and flower yield in garland chrysanthemum**

| Treatments | Number of flowers per plant | | | | | Flower yield | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Per plant (g) | | | | | Per hectare (q) | | | | |
| | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean | $K_{50}$ | $K_{100}$ | $K_{150}$ | $K_{200}$ | Mean |
| $N_{50}$ | 7.63 | 10.04 | 11.07 | 12.90 | 10.40 | 12.50 | 16.73 | 17.07 | 17.38 | 15.92 | 3.80 | 6.50 | 7.33 | 7.70 | 6.58 |
| $N_{100}$ | 10.27 | 11.20 | 13.90 | 14.90 | 12.57 | 17.53 | 17.97 | 15.60 | 18.50 | 17.50 | 8.10 | 8.40 | 9.48 | 9.90 | 8.97 |
| $N_{150}$ | 14.67 | 15.20 | 16.87 | 17.20 | 15.99 | 18.37 | 19.57 | 20.57 | 21.00 | 20.61 | 9.95 | 11.83 | 12.30 | 12.74 | 11.71 |
| $N_{200}$ | 18.50 | 20.00 | 28.00 | 22.00 | 22.13 | 25.05 | 24.21 | 36.00 | 30.00 | 25.38 | 13.50 | 14.00 | 25.25 | 20.75 | 18.38 |
| Mean | 12.77 | 14.10 | 17.46 | 16.75 | 15.27 | 18.36 | 19.62 | 22.31 | 21.72 | 19.85 | 8.09 | 10.18 | 13.59 | 12.77 | 11.41 |
| | S.E.± | | C.D. (P=0.05) | | | S.E.± | | C.D. (P=0.05) | | | S.E.± | | C.D. (P=0.05) | | |
| N | 0.47 | | 1.34 | | | 0.38 | | 1.10 | | | 0.46 | | 1.35 | | |
| K | 0.47 | | 1.34 | | | 0.38 | | 1.10 | | | 0.46 | | 1.35 | | |
| N × K | 0.88 | | 2.57 | | | 0.78 | | 2.09 | | | 0.88 | | 2.56 | | |

rate of 50 kg ha$^{-1}$ (15.92 g and 6.58 q, respectively). Application of potassium at the rate of 150 kg ha$^{-1}$ recorded significantly highest flower yield per plant and per hectare (22.31 g and 13.59 q, respectively) and was found at par with the application of 200 kg ha$^{-1}$, whereas, application of potassium at the rate of 50 kg ha$^{-1}$ recorded significantly lowest flower yield per plant and per hectare (18.36 g and 8.09 q, respectively). Among the combinations, application of nitrogen and potassium at the rate of 200 and 150 kg ha$^{-1}$, respectively recorded significantly highest flower yield per plant and per hectare (36.00 g and 25.25 q, respectively), whereas, application of nitrogen and potassium each at the rate of 50 kg ha$^{-1}$ recorded significantly lowest flower yield per plant and per hectare (12.5 g and 3.80 q, respectively). Based on the results obtained it may be concluded that number of flowers per plant and per hectare increased by application of graded doses of nitrogen and potassium in different combinations. Yield of flowers per plant and per hectare increased by application of nitrogen mainly because of increased carbohydrate reserve for the development of floral primordia apart from the structural development of plant. The present result is in confirmation with the earlier findings of Agrawal *et al*. (2002); Sharma *et al*. (2006) and Rajbeer and Jitendra (2009) in African marigold who obtained significantly higher yield by application of higher levels of nitrogen.

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