

**EFFECT OF N, P AND K APPLICATION AT  
DIFFERENT STAGES IN CHRYSANTHEMUM  
(*Chrysanthemum morifolium* Ramat)**

*Thesis*

by

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(H-2018-105-M)**

submitted to



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## **CERTIFICATE-I**

This is to certify that the thesis titled “**Effect of N, P and K application at different stages in chrysanthemum (*Chrysanthemum morifolium* Ramat)**” submitted in partial fulfilment of the requirements for the award of degree of **Master of Science (Horticulture) Floriculture and Landscape Architecture** in the discipline of **Horticultural Sciences** to Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) – 173 230 is a bonafide research work carried out by **Ms Deachen Dolma (H-2018-105-M)** daughter of Sh Stanzin Wangtak under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been fully acknowledged.

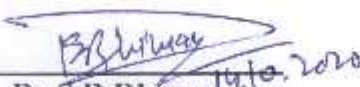
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## CERTIFICATE-II

This is to certify that the thesis titled, “Effect of N, P and K application at different stages in chrysanthemum (*Chrysanthemum morifolium* Ramat)”, submitted by Ms. Deachen Dolma (H-2018-105-M) daughter of Sh. Stanzin Wangtak to the Dr Yashwant Singh Parmar University of Horticulture and Forestry, (Nauni) Solan (HP) – 173 230 India in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE) FLORICULTURE AND LANDSCAPE ARCHITECTURE** in the discipline of **HORTICULTURAL SCIENCE** has been approved by the Advisory Committee after an oral examination of the student in collaboration with an Internal Examiner.

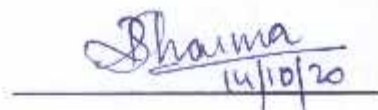
  
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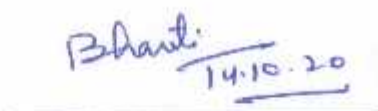
  
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(Deachen Dolma)

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## **ABBREVIATIONS**

|                   |   |                           |
|-------------------|---|---------------------------|
| %                 | : | Per cent                  |
| &                 | : | and                       |
| /                 | : | per                       |
| @                 | : | At the rate of            |
| +                 | : | Plus                      |
| °C                | : | Degree Centigrade         |
| amsl              | : | above mean sea level      |
| ANOVA             | : | Analysis of variance      |
| B:C               | : | Benefit cost ratio        |
| BF                | : | Biofertilizers            |
| CD                | : | Critical difference       |
| cm                | : | Centimeter                |
| B                 | : | Boron                     |
| cv.               | : | Cultivar                  |
| df                | : | degree of freedom         |
| ds/m              | : | Deci siemens per meter    |
| e.g.              | : | For example               |
| EC                | : | Electrical conductivity   |
| <i>et al.</i>     | : | Co-worker                 |
| etc.              | : | et cetera (and so on)     |
| FYM               | : | Farm yard manure          |
| Fig.              | : | Figure                    |
| g                 | : | Gram                      |
| kg/m <sup>2</sup> | : | Kilogram per square meter |
| ha                | : | Hectare                   |
| HP                | : | Himachal Pradesh          |
| i.e.              | : | that is                   |
| K                 | : | Potassium                 |
| kg                | : | Kilogram                  |
| l                 | : | Litre                     |
| m                 | : | Meter                     |
| m <sup>2</sup>    | : | Square meter              |

|        |   |                                   |
|--------|---|-----------------------------------|
| mg     | : | Milligram                         |
| ml     | : | Millilitre                        |
| mm     | : | Millimeter                        |
| N      | : | Nitrogen                          |
| NS     | : | Non-significant                   |
| NPK    | : | Nitrogen : Phosphorus : Potassium |
| OC     | : | Organic carbon                    |
| P      | : | Phosphorus                        |
| pH     | : | Potential of hydrogen             |
| PSB    | : | Phosphate solubilizing bacteria   |
| q /ha  | : | Quintal per hectare               |
| RCBD   | : | Randomized complete block design  |
| RDF    | : | Recommended dose of fertilizers   |
| RDN    | : | Recommended dose of nitrogen      |
| Rs.    | : | Rupees                            |
| t      | : | Tonne                             |
| T      | : | Treatment (s)                     |
| t/acre | : | Tonne per acre                    |
| t/ha   | : | Tonne per hectare                 |
| var.   | : | Variety                           |
| VAM    | : | Vesicular arbuscular mycorrhiza   |
| VC     | : | Vermicompost                      |
| Viz.   | : | <i>videlicet</i> (namely)         |

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## ***Chapter -1***

# **INTRODUCTION**

---

Chrysanthemum (*Chrysanthemum morifolium* Ramat) is a popular flower crop of commercial importance. It belongs to the family Asteraceae. It is native to the northern hemisphere, primarily Europe and Asia (Dowrick 1952b and Hemsley, 1889). It is believed to be originated from China (Carter, 1980). It is the national flower of Japan.

It is commonly known as ‘Autumn Queen’, Queen of the East or Guldaudi. Crook (1942) noted “chrysanthemum is the flower of the East, as the rose is the flower of the West.” It is important both as cut flower and potted plant. In the Netherlands, chrysanthemum is ranked as the second cut flower in Dutch auctions (800 million stems) and fifth in potted plant rankings. In India, in addition to its use as a cut flower and pot plant, its flowers are also used for making garlands, venis, gajaras and presented in religious offerings. Its wide demand is due to its large number of cultivars with respect to its growth habit, size, colour, and shape of bloom. There are about 20,000 cultivars of chrysanthemum all around the world out of which 500 are being grown in India (Datta and Battercharjee, 2001). As a short-day plant, it naturally flowers in the autumn and winter. Through environmental manipulation it can be grown all over the year under controlled conditions.

In the mid hill conditions of Solan district of Himachal Pradesh, it is generally planted in the month of June. Chrysanthemum plants can be propagated both sexually and through vegetative means. A commercial method of propagation is by way of shoot tip cuttings taken from healthy mother plants (Mukherjee, 2008). These are also propagated by means of suckers but result in producing tall plants which are not considered suitable for decorative purpose.

The varied agro-climatic conditions of our country are highly suitable for the cultivation of chrysanthemum throughout the year as a result of which it can be grown in almost every part of the country. The planting time for the crop in the hills is different than that in the plains. It is being grown in almost every flower growing district of Himachal Pradesh. The total area under floriculture in Himachal Pradesh is 705.77 hectares out of which about 222.11 hectares is under chrysanthemum cultivation (Anonymous, 2019).

Apart from the various factors influencing the growth and flowering of chrysanthemum, balanced nutrition is very important. Chrysanthemum is a heavy feeder crop and among all the essential nutrients, it requires larger quantities of nitrogen, phosphorous and potassium. Lunt and Kofranek (1958) advocated maintaining high levels of N during the first seven weeks of chrysanthemum growth. Plant requires phosphorous throughout their growing period and it should be applied as a basal dose.

Nutrition plays an important role for higher and better quality of flower yield. Application of major nutrients viz. nitrogen, phosphorus and potassium play an important role in the growth and development of flower crops thereby increase the flower yield.

Nitrogen acts as an essential part in the biosynthesis of nucleic acids, hence, plays a vital role in promoting the plant growth. Further, nitrogen has been identified as an important constituent of chlorophyll, proteins and amino acids, thereby enhancing the rate of photosynthesis. It is essential for the creation of biomass as well as for the biosynthesis of enzymes in chrysanthemum leaves (Liu *et al.*, 2010).

Phosphorus has a great role in energy storage and transfer. It is also a constituent of majority of enzymes which are of great importance in the transformation of energy, in carbohydrate and fat metabolism and also in plant respiration. Phosphate compound serve as the plant's energy currency by stimulating early root growth and development in turn leading to early seedling emergence.

Potassium plays a vital role in the cell division and cellular differentiation in the plant system by increasing the number of primary branches per plant. The lower or deficient application of potassium reduces the plant height leading to stunted growth. It increases the rate of carbon exchange thereby enhancing the movement of photosynthesis in the phloem tissue which leads to an increase in the meristematic activity of the plant system. In chrysanthemum potassium requirement is high and its presence in the plant favorably affects the growth and flower colour (Vanek *et al.*, 2012).

Chrysanthemum has a shallow and fibrous root system. It is a heavy feeder. In traditional system of practices nitrogen application was split into two doses, one as basal dose with full dose of phosphorus and potassium and remaining nitrogen after 40 days of transplanting. Split application of nutrients can play an important role in the nutrient

management strategy that is productive, profitable and environmentally responsible. Dividing total nutrient application into splits can help growers enhance nutrient efficiency, promote optimum yields and mitigate the loss of nutrients. Split application offers efficiency benefits on a wide range of crop but its management must be considered on a crop by crop basis. The timing of post planting application is especially critical. Keeping this in view, the present investigation is planned to study the effect of nitrogen, phosphorus and potassium through basal application (granular form) followed by fertigation at different phenophase stages i.e. vegetative, bud and flowering on flower yield and quality of chrysanthemum. Keeping in view the above mentioned facts, the present study was taken with following specific objective:

- To work out growth based N, P and K dose for production of quality flower in chrysanthemum.

## Chapter -2

# REVIEW OF LITERATURE

---

Chrysanthemum is a heavy feeder crop. It has large requirements for nitrogen, phosphorus and potassium. Nitrogen, phosphorus and potassium play a vital role in the production of quality flowers. Application of fertilizers is the most important factor which directly influences the yield of the crop. Little investigation has been done to study the effects of nutrition on particular stages of growth especially during the later stages of vegetative growth and the period of transition to reproductive growth. Chrysanthemums have high requirements for both nitrogen and potassium. Lunt and Kofranek (1958) advised that maintenance of high levels of nitrogen during the first 7 weeks of growth is especially important.

Manurial schedule of N, P and K plays a major role in successful production of chrysanthemum (Lunt and Kofranek, 1958; Hansen and Lynch, 1998). The nutrient requirements at different growth stages of chrysanthemum was determined by Kazimirova (1975) who observed that requirement of all the basic three nutrients (N, P and K) were maximum during vigorous growth, especially N and K requirement dose remained high until flowering. Denisen (1982) reported that high nitrogen with appropriate dose of phosphorus and potassium seemed to have increased vegetative growth at early stages. Yoon *et al.* (2000) observed that chrysanthemum take up nitrogen at an even rate from the time of planting to the flowering stage and after that nitrogen uptake decreases. In chrysanthemum, the need for phosphorus is significantly lower than that of nitrogen (Li *et al.*, 2009). Potassium requirements are high and its presence in the plant favorably affects growth and flower colour (Vanek *et al.*, 2012).

The relevant literature on effect of N, P and K dose for production of quality flower in chrysanthemum (*Chrysanthemum moifolium* Ramat) has been reviewed in this chapter: Application of nutrients particularly nitrogen, phosphorus and potassium to chrysanthemum plants result in increased vegetative as well as flowering parameters.

Increase in stem length and the weight of the tops of chrysanthemum plants was noted with the higher doses of nitrogen (Chan, 1960). Joiner and Smith (1962) also obtained increase in the stem length and diameter of plants of chrysanthemum cv. 'Blue Chip' with

200 ppm nitrogen, when they tried a nitrogen range of 50-300 ppm in sandy soils. Favorable increase in stalk length and flower diameter in chrysanthemum have also been noted by Winsor and Hart (1965).

Kochkin and Kazimirova (1971) found a high positive correlation between flower production and N and P contents of soil. Butters (1970) observed that application of high level of N increased the size of flower in chrysanthemum.

Kumar and Shanmugavella (1978) noticed that the increase in nitrogen level stimulated early flowering in chrysanthemum. Hosoya *et al.* (1978) observed that nitrogen improved the vegetative growth of chrysanthemum in the initial stages.

Komosa (1982) conducted an experiment on high and low critical levels of nitrogen, phosphorus and potassium for *Chrysanthemum morifolium* cv. 'Balcombe Perfection' and observed that optimum nutrient levels of 150-450 mg N-NO<sub>3</sub>, 80-2200 mg P-PO<sub>4</sub> and 150-1200 mg K per litre resulted in the best growth and quality of chrysanthemum plants.

Kumar *et al.* (1982) found that maximum plant height and plant spread of chrysanthemum were at 20:120:20 kg NPK/ha. On the other hand, Samoilenko (1983) recommended that application of 80 kg N/ha, 160 kg P/ha and 80 kg K/ha produced best growth and quality flowers of chrysanthemum.

Strojny (1985) reported that application of nitrogen at 5 g/m<sup>2</sup> applied monthly in chrysanthemum produced good plant growth and flower production of chrysanthemum. Rachayanavar (1985) stated that application of 250 kg N/ha in chrysanthemum resulted in maximum number of branches per plant.

Chezhiyan *et al.* (1986) in their studies with chrysanthemum cv. 'CO-1' reported maximum plant height, number of flowers and branches per plant and yield per hectare was obtained using 20 g N and P<sub>2</sub>O<sub>5</sub>/m<sup>2</sup> each with 10 g K<sub>2</sub>O/m<sup>2</sup>.

Singh and Dadlani (1988) recommended an application of combined dose of 40 g N and 20 g P<sub>2</sub>O<sub>5</sub> for maximum number of flowers in chrysanthemum.

Cut-flower chrysanthemum cultivars 'Foxy' and 'Yellow Snowdon' were supplied with different amounts of nitrogen, phosphorus and potash as the basal fertilizers and in

subsequent applications. Increasing doses of nitrogen increased the fresh weight, reduced stem length and shortened the growth period. It is recommended that the plants should be started in spring on substrate containing 200 ppm nitrogen and water 5 times weekly with 3 litres/m<sup>2</sup> of a solution containing 0.8 to 1.2 g/l of complete fertilizer with 15 per cent nitrogen (Grantzau and Scharof, 1986).

An experiment was conducted at Kalyani centre of AICFIP in West Bengal, and recommended 40 g each of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O per meter square for maximum yield in chrysanthemum. Half the dose of N and full dose of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O was applied at the time of planting and the remaining half dose of N was given 40 days after the planting (Kher, 1986).

Lodhi *et al.* (1990) in the study with chrysanthemum cv. 'Flirt' supplied the plants with nitrogen at 0, 15, 30, 45 and 60 g/m<sup>2</sup> and phosphorus at 0, 15, 30, 45 g/m<sup>2</sup> in all possible combinations along with a common dose of 15 g/m<sup>2</sup> potash and 5 kg FYM/m<sup>2</sup> as a basal dressing. Delay in bud formation and duration of flowering was observed with increased levels of nitrogen.

Yassin and Pappiah (1990) conducted field trials on chrysanthemum cv. 'MDU-1' on soils low in available nitrogen and high in potash with moderate levels of phosphorus. The plants were supplied with nitrogen (as urea) at 100 kg/ha or 25 kg/ha as sheep manure + 75 kg/ha as urea. These plants were or were not pinched on the 30<sup>th</sup> or 60<sup>th</sup> day after planting. The maximum flower yield (253.82 g/plant) was obtained with plants pinched on 60<sup>th</sup> day and fertilized with sheep manure + urea.

Sastry and Singh (1990) evaluated the effect of P and K on the flower yield, plant height and diameter of pyrethrum plants. A significant increase in flower yield was observed when the level of P was increased up to 120 kg/ha in the 1<sup>st</sup> and 3<sup>rd</sup> year and up to 180 kg/ha in the 2<sup>nd</sup> year. Potassium also increased the flower yield of pyrethrum up to a level of 80 kg/ha K<sub>2</sub>O. However, treatments of P and K did not seem to affect the plant height or the plant diameter.

Roa *et al.* (1992) carried out field experiment and obtained significantly increased weight of flowers per plant in chrysanthemum cv. 'Kasturi' with increasing N application rates 50 to 200 kg/ha.

Belgaonkar *et al.* (1996) studied the effects of levels of nitrogen and phosphorus with different spacing on growth and yield of annual chrysanthemum. N and P ( $P_2O_5$ ) were each applied at 100, 150 or 200 kg/ha and plants were spaced at 30×45, 45×45 or 60×45cm. Plant were tallest (118.89 cm), had more primary and secondary branches (34.47 and 182.95), and took fewer days for flower to open when 200 kg N and 200 kg  $P_2O_5$ / ha were applied.

Mostafa (1996) in a greenhouse pot trial with chrysanthemum cv. 'Wilson's White' plants, applied nitrogen and potash at different N and K ratios of 0:0, 1:0, 2:0, 0:1, 1:1, 2:1, 0:2, 1:2 and 2:2 (1=9.6 g/plant) through ammonium sulphate and potassium sulphate, respectively, three weeks after final transplanting. Maximum plant height and leaf numbers per branch were found with 9.6 g/plant nitrogen application .

De and Barman (1997) conducted studies on chrysanthemum cultivars 'Yellow Anemone', 'Yellow Pompon', 'Maharaja' and 'Bajoria Red' plant were supplied with 0, 5, 10, 15 and 20 g N/m<sup>2</sup> during winter. Plant height and leaf number per plant were improved significantly under 15-20 g N/m<sup>2</sup>.

Khankhane *et al.* (1997) reported revealed the highest growth of chrysanthemum obtained by application of 15 g nitrogen/m<sup>2</sup> and 16 g potassium/m<sup>2</sup>. Vaghasia (1997) carried an experiment with four levels of nitrogen (50, 100, 150, 200 kg N/ha) and reported that application of 200 kg N/ha in chrysanthemum resulted in maximum flower yield.

Baboo and Sharma (1997) found that application of 300 kg of N and 160 kg of  $K_2O$  along with 200 kg  $P_2O_5$  per hectare significantly increased the plant height and number of branches per plant in chrysanthemum. Kander and Zearche (1997) observed that application of 200 mg/l of nitrogen resulted in good rooting in *Chrysanthemum morifolium*.

In a study on hydroponic cultivation of chrysanthemum, nitrogen application reduced by half to 217 mg per litre when sulphur was supplied at 4 mg per litre in the autumn and 8 mg per litre in the spring was found best (Huang *et al.*,1997).

Tripathi (1997) recommended a basal dose of 5 kg FYM, 40 g N, 20 g  $P_2O_5$  and  $K_2O$  per square meter each for influencing the various growth and flowering parameters in chrysanthemum. Gowda and Jayanti (1988) reported that in chrysanthemum 30 g/m<sup>2</sup> nitrogen and 20 g/m<sup>2</sup> potassium obtained maximum number of flowers per plot. Schuch *et al.* (1998)

observed that leaf area was increased when nitrogen fertilizer was raised from 80 to 160 mg/l in chrysanthemum.

De and Dhiman (1998) studied the effect of N, P and K on the production of cut flowers of chrysanthemum cv. 'Chandrama'. The combination of 600 kg N and 200 kg K<sub>2</sub>O/ha recorded maximum number of flowers per plant.

Barman and Pal (1999) observed appreciable improvement in the vegetative and floral attributes of chrysanthemum cv. 'Chandrama' when the plants were applied with 30 g N and 20 g K per square meter area.

Jhon and Paul (1999) conducted studies on the plants of chrysanthemum cv. 'Flirt' supplied with different levels of nitrogen (0, 10, 20, 30 and 40 g/m<sup>2</sup>) and phosphorus (0-30 g/m<sup>2</sup>) in silty loam soils. They recommended the use of 10 g nitrogen/m<sup>2</sup> for improving the vegetative growth of these plants.

Sawaan *et al.* (1999) conducted a greenhouse trial on *Chrysanthemum morifolium* cv. 'Romano' supplied with different nitrogen rates (50, 100, 150, 200, 250 or 300 ppm) in three forms (NO<sub>3</sub>, NH<sub>4</sub> and urea). Maximum height of plants was observed with 50 ppm nitrogen when supplied through CaNO<sub>3</sub>. It was further observed that diameter and the peduncle length was not affected by any of the nitrogen rates or source.

Gopal (1999) conducted an experiment on fertigation of chrysanthemum under greenhouse conditions with five treatments comprising of 60, 80, 100 and 120 per cent of recommended dosage and revealed that 80 per cent fertigation level resulted in least number of days for the initiation of flower and better length of stalk. A level of 100 per cent fertigation recorded the maximum flower yield and vase life.

Datta and Bhattacharjee (2001) compiled the work on NPK studies of chrysanthemum from various research stations under AICRP on floriculture and following are the recommendations for various regions.

| Centre     | Recommended dose (kg/ha) |                               |                  |
|------------|--------------------------|-------------------------------|------------------|
|            | N                        | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O |
| Coimbatore | 300                      | 200                           | 200              |
| Kalyani    | 300                      | 200                           | 200              |
| Pune       | 300                      | 200                           | 200              |
| Bangalore  | 400                      | 400                           | 200              |

Karavadia and Dhaduk (2002) conducted an experiment on annual chrysanthemum cv. 'Local White' and observed that application of higher dose of N (150 kg/ha) produced significantly maximum number of branches, plant spread, main stem diameter, fresh and dry weight of plant.

An experiment was conducted on chrysanthemum to find out the effect of nitrogen and phosphorus on growth, flowering and yield of cv. 'Local White'. The four nitrogen levels (0, 10, 20 and 30 g/m<sup>2</sup>) and three phosphorus levels (0, 10 and 20 g/m<sup>2</sup>) were applied. The application of 20 g nitrogen and 10 g phosphorus with 10 g potash per m<sup>2</sup> resulted in maximum growth of plant, flowering and yield (Dixit *et al.*, 2004).

Beniwal *et al.* (2005) conducted an experiment on the effect of nitrogen and phosphorus levels on flowering and yield of chrysanthemum (*Chrysanthemum morifolium*) cv. 'Flirt'. The four levels of nitrogen (0, 10, 20 and 30 g/m<sup>2</sup>) and three levels of phosphorus (0, 10, 20 g P<sub>2</sub>O<sub>5</sub> g/m<sup>2</sup>) along with common dose of potassium @ 20 g/m<sup>2</sup> and 5 kg of FYM per square meter were applied in randomized factorial block design with three replications. It was found that application of nitrogen and phosphorus each @ 20 g/m<sup>2</sup> significantly improved the flowering (days to bud formation, days to first flowering, duration of flowering and size of flower) and yield parameters (number of flowers/plant, fresh weight of flower and flower yield) .

Anjaneyulu *et al.* (2005) are of the opinion that the application of N and P at 20 g/m<sup>2</sup> significantly improved the flowering (days to bud initiation, days to first flowering, duration of flowering and size of flower) and yield parameters (number of flowers per plant, fresh weight of flower and flower yield) of twenty four exotic cultivars of chrysanthemum.

Sharma *et al.* (2006) carried out an experiment to investigate the effect of NPK nutrition on growth and flowering of chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. 'Snowball'. The treatments comprised of four levels of nitrogen i.e. N<sub>1</sub>= 0.0 g/m<sup>2</sup>, N<sub>2</sub>= 15.0 g/m<sup>2</sup>, N<sub>3</sub>= 30.0 g/m<sup>2</sup>, N<sub>4</sub>= 45.0 g/m<sup>2</sup> and three levels of each of phosphorus and potassium i.e. P<sub>0</sub> & K<sub>0</sub>= 0.00 g/m<sup>2</sup>, P<sub>1</sub>& K<sub>1</sub>= 15.0 g/m<sup>2</sup>, P<sub>2</sub>K<sub>2</sub>= 30.0 g/m<sup>2</sup>, respectively. An application of 30 g/m<sup>2</sup> of NPK was found effective in increasing vegetative parameters.

Budiarto *et al.* (2006) suggested that supplemented NPK (2.5 g/l) every 4 days during rooting in chrysanthemum cuttings in carbonized rice husk increased the performance and quality of cut flowers.

Deshmukh *et al.* (2006) conducted an experiment with different levels of N (0, 15, 30 and 45 g/m<sup>2</sup>) and P (0, 20, 40 and 60 g/m<sup>2</sup>) supplied to chrysanthemum (*Dendranthema morifolium*) in a polyhouse. The results revealed that application of N @ 45 g/m<sup>2</sup> + P @ 40 g/m<sup>2</sup> produced maximum plant height (100.20 cm). Maximum fresh and dry weights of shoot and root, number of primary branches and flower number per plant were produced with the application of N at 30 g/m<sup>2</sup> + P at 40 g/m<sup>2</sup>.

The application of nitrogen @ 300 and phosphorus @ 150 kg/ha in chrysanthemum cv. 'Nilima' was found to be the optimum dose for obtaining higher flower yield per hectare (Chawla *et al.*, 2007).

Verma *et al.* (2007) investigated the influence of nitrogen and potassium levels on postharvest quality of cut flowers of chrysanthemum (*Dendranthema grandiflora*) cv. 'Snow Ball'. Maximum vase life was noted (19.27 days) with 20 g/m<sup>2</sup> K and maximum flower size was recorded (13.03 mm) in 40 g/m<sup>2</sup> K treatment. Maximum percent physiological loss in weight was noticed in 60 g/m<sup>2</sup> N.

Jiang *et al.* (2008) conducted an experiment to determine the effect of N, P and K ratio on the growth and development of cut chrysanthemum cv. 'Jinba'. They concluded that the optimum application level of N, P and K was 14.3: 2.0: 8.0 during the vegetative growth stage and 7.1: 4.0: 12:0 during the reproduction stage.

Reza and Gopinath (2009) investigated the effect of mulching and fertigation on growth, yield and quality of chrysanthemum var. 'Chandini'. The experiment consisted of two factors namely fertigation levels (control, 80 and 100 per cent recommended dose of fertilizers where RDF is 120:150:100 kg NPK/ha) and plastic mulching (control, 25µ thickness and 50µ thickness). Economically feasible cost benefit ratio was observed with water soluble fertilizers at 100 per cent recommended dose of fertilizers provided through fertigation in splits at fortnightly interval with 50µ black polythene mulch. The maximum growth and quality in chrysanthemum crop was obtained by application of water soluble fertilizers at 100 per cent of recommended dose of fertilizers through fertigation with 50µ black polythene much under open condition.

Parekh *et al.* (2010) conducted an experiment on the response of N, P and K on growth and flower production of chrysanthemum (*Chrysanthemum morifolium* Ramat) cv.

‘IIHR-6’. The experiment comprised of three levels of nitrogen (100, 200, 300 kg/ha), two levels of phosphorus (0, 100 kg/ha) and two levels of potash (0, 100 kg/ha). The maximum plant height was recorded from N<sub>1</sub> (100 kg/ha) and P<sub>1</sub> (0 kg/ha). The different levels of potash on plant height were found non-significant.

Dorajeerao and Mokashi (2010) conducted an experiment on standardization of production technology in garland chrysanthemum (*Chrysanthemum coronarium* L.) The experiment on the effect of nutrition revealed that flower and seed yield per plant was found to be highest by the application of nitrogen at 150 kg/ha + phosphorus at 100 kg/ha both during kharif and rabi with a constant dose of potassium at 100 kg/ha.

Patel and Chaudhari (2011) evaluated the effect of different levels of nitrogen (100, 150 and 200 kg/ha) on different varieties ‘IIHR-6’, ‘Flirt’ and ‘Shyamal’ of chrysanthemum. Cultivar ‘Flirt’ varieties performed better than ‘Shayamal’ and ‘IIHR-6’ with 200 kg N per hectare by recording maximum number of flower per plant, flower yield per plant and flower yield per hectare.

Laishram (2011) observed that maximum plant height (63.65 and 78.04 cm) and length of side shoots (95.75 and 67.60 cm) was noted with the application of 22.5 g/m<sup>2</sup> each of NPK + vermicompost (1 kg/m<sup>2</sup>) + biofertilizers in cultivars ‘Purnima’ and ‘Ajay’, respectively.

Joshi *et al.* (2013) conducted an experiment to investigate the performance of varieties and chemical fertilizers on growth and flowering in chrysanthemum. The three levels of nitrogen (100, 200 and 300 N kg/ha), two levels of phosphorus (100 and 150 kg P<sub>2</sub>O<sub>5</sub>/ha) and two levels of potash (100 and 150 kg K<sub>2</sub>O per/ha) were selected. Application of nitrogen @ (300 kg/ha) resulted in highest plant height, number of branches, leaf area, fresh and dry weight of plant. Potassium failed to influence all of these growth and flowering parameters.

Janakiram *et al.* (2013) advocated to apply 10-12 t/ha of well decomposed farm yard manure and 50 kg of nitrogen, 160 kg P<sub>2</sub>O<sub>5</sub> and 80 kg K<sub>2</sub>O/ha as basal dose in chrysanthemum. Top dress the crop with 50 kg N/ha at the time of first pinching.

Ganesh *et al.* (2014) worked on optimization of fertigation schedule for cut chrysanthemum (*Dendranthema grandiflora* Tzvelev) and found that 75 % of recommended

dose of fertilizers at the rate of 12:3:12 g NPK/m<sup>2</sup> along with foliar spray of 0.2 % EDTA micronutrient mixture at 15 days intervals will improve the growth, physiology, yield and quality of cut chrysanthemum.

Chopde *et al.* (2015) studies the response of annual chrysanthemum genotypes to different levels of nitrogen. The four genotypes of annual chrysanthemum viz. 'NAC-04', 'NAC-07', 'NAC-10' and 'NAC-12' and four levels of nitrogen viz. 0 , 50 , 100 and 150 kg/ha were selected. The higher dose of nitrogen (150 kg N/ha) was found significantly superior over all other levels except 100 kg N/ha in respect of plant height, branches per plant, flowering span, flower yield per hectare, flower diameter and number of petals. Interaction effect of genotypes of annual chrysanthemum and various nitrogen levels on all the character was found non-significant except days for initiation of first flower bud.

Hassanein (2015) investigated the influences of irrigation frequency and method of fertilization on the growth and flowering of chrysanthemum grown under restricted root volume. To study the effect of water regime, chrysanthemum cuttings were grown in pots and plants were irrigated regularly at 1, 2, 4 or 8 week intervals during growth period. In another pot experiment, the effect of fertilization method was tested as either foliar spray method at rates of 1.5, 3.0 and 6.0 g/l or fertigation application (in irrigation water) at rates of 7.5, 15 and 22.5 g/l. The results showed that plants that were irrigated weekly and fertilized with 3.0 g/l as foliar spray produced the tallest plant values but flowering was inhibited. While plants irrigated at two weeks interval and fertilized with 15.0 g/l as fertigation method showed better flowering and produced the highest number of flowers per plant. It is evident that the number of flowers were affected by both irrigation frequencies and application method of fertilization. Irrigation frequency and method of fertilization can improve the growth and flowering of chrysanthemums grown in pots with restricted volume of soil.

Satar *et al.* (2016) carried out an investigations on annual chrysanthemum with four levels of nitrogen viz. (0, 100, 150 and 200 kg/ha and four levels of phosphorus viz. (0, 50, 75 and 100 kg/ha). The application of nitrogen 200 kg/ha and phosphorus 100 kg/ha significantly increased plant height, number of primary branches, diameter of main stem, plant spread, number of flower per plant and yield per plant and per hectare.

Mali *et al.* (2016) studied the effect of planting geometry and nitrogen on growth, flowering and yield of chrysanthemum (*Chrysanthemum coronarium* L.). The four nitrogen

levels ( $N_0$  - 0 kg,  $N_1$  - 100 kg,  $N_2$  - 150 kg,  $N_3$  - 200 kg N/ha) were tested. Application of nitrogen at different levels and planting geometries significantly influenced the number of days taken for first flower bud appearance and 50 per cent flowering with the earliest first flower bud appearance (47.33 days) and 50 per cent flowering (64.83 days) at  $S_1$  (30 cm  $\times$  30 cm spacing). Similarly nitrogen at  $N_0$  (0 kg/ha) had the earliest first flower bud appearance (46.75 days) and 50 per cent flowering (63.25 days), while nitrogen at  $N_3$  (200 kg/ha) had the latest first flower bud appearance (55.33 days) and 50 per cent flowering (69.42 days).

Ganesh *et al.* (2016) conducted studies on spray chrysanthemum var. 'Punch' under different fertigation levels. It comprised of 75 %, 100 %, 125 % and 150 % of fertigation level along with foliar spray of 0.2% EDTA chelated micronutrient mixture to each of the treatment. The results revealed that T6 (75 % RDF @ 12:3:12 g NPK/m<sup>2</sup> with foliar spray of 0.2 % EDTA chelated micronutrient mixture) was found to increase the physiological responses of the spray chrysanthemum which ultimately effect on the improvement in flowering and yield per unit area.

The application of nitrogen at the rate of 200 kg per hectare in combination with potassium at the rate of 150 kg per hectare along with common dose of phosphorus at the rate of 100 kg per hectare resulted in maximum 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 (Teja *et al.*, 2017).

Ahmed *et al.* (2017) evaluated the response of different doses of N, P and K on the yield and yield attributes of chrysanthemum var. 'Bari' to find out the optimum and economic doses of NPK for maximizing yield of chrysanthemum. The four levels of nitrogen (0, 100, 150 and 200 kg/ha), phosphorus (0, 50, 75 and 100 kg/ha) and potassium (0, 90, 135 and 180 kg/ha) along with blanket dose of 2 kg B and 4 kg Zn/ha were used. Highest flower yield was obtained with the application of 150 kg N, 75 kg P and 135 kg K per hectare along with blanket dose of 2 kg B and 4 kg Zn/ha.

Janipour *et al.* (2017) studied on the influence of nitrogen nutrition in topiary of chrysanthemum (*Chrysanthemum grandiflorum*). The experiment consisted of 4 nitrogen levels 0, 100, 150 and 200 mg/kg soil using ammonium nitrate as a fertilizer source to increase the beauty performance in topiary of chrysanthemum. To ensure proper growth of chrysanthemum branches in topiary form, furnishing of 200 mg N per kg of soil on vegetative

growth stage and feeding reduction to 100 mg per kg of soil for the flowering process is appropriate and advisable.

Thakur and Grewal (2017) conducted an experiment to standardize the nitrogen application for the standard potted *Chrysanthemum morifolium* cv. 'Snowball'. The six treatments i.e. control, 100, 200, 300, 400 and 500 mg/pot nitrogen (urea) was applied twice in mid September and mid-October. It was concluded that 300 mg urea/pot applied twice was optimum dose of nitrogen application for quality pot plant production.

Verma *et al.* (2017) conducted an experiment with the objectives to effect of nitrogen, phosphorus and potash on growth and flower yield of pyrethrum (*Chrysanthemum cinerariifolium*). The different levels of nitrogen (0, 60, 80, 100 and 120 kg/ha/year), phosphorus (0, 40, 80, 100 and 120 kg/ha/year), and three levels of potash (0, 40 and 60 kg/ha/year). The growth parameters viz. plant diameter, number of flower and flower yield were significantly higher with nitrogen, phosphorus and potash @ 100 kg/ha, 100 kg/ha and 60 kg/ha respectively which was at par with 80 kg/ha, 100 kg/ha and 40 kg/ha respectively.

Chaitra *et al.* (2018) studied the effect of different levels of nutrients (NPK) and mulching on various growth and flowering traits of chrysanthemum (*Dendranthema grandiflora* Tzvelev.) cv. 'Marigold'. The treatments consisted of different levels of nutrients and mulching, viz. 75 % recommended dose of fertilizer (RDF) mulching, 100 % RDF with mulching, 125 % RDF with mulching and 100 RDF without mulching (control) and RDF was 120:150:100 kg NPK per ha. The application of 150 % RDF with mulching increased plant height, leaf area, plant spread, number of suckers, bud initiation, flower diameter, highest flower yield per plant, number of sprays per plant and yield per ha. However, maximum shelf life was recorded from 125 % RDF with mulching after 120 days of planting.

Nikam *et al.* (2018) studied the effect of nitrogen and potassium on growth and flowering of annual chrysanthemum. The treatments comprised of four levels of nitrogen (0, 100, 150 and 200 kg N/ha) and four levels of potassium (0, 50, 75 and 100 kg K/ha). The results revealed that plant height, stem diameter, number of branches, plants spread and leaf area were recorded maximum with the application of 200 kg nitrogen and 75 kg potassium per hectare and yield contributing characters like number of flower per plant, number of seed per flower and seed yield per flower were recorded significantly maximum with the same treatment.

Rajan *et al.* (2019) studied the effect of nitrogen and phosphorus on growth, flowering and yield of cut chrysanthemum cv. 'Thai Chen Queen'. The four levels of nitrogen (100, 150 and 200 kg N/ha) and three levels of phosphorus (50, 75 and 100 kg P<sub>2</sub>O<sub>5</sub>/ha) were used. The result revealed that application of 200 kg N/ha to cut chrysanthemum was most effective to increase plant height however, plants receiving 150 kg N/ha significantly improved vegetative growth as well as quality and yield of flowers. Application of 75 kg P<sub>2</sub>O<sub>5</sub>/ha was found promising for growth, quality as well as yield parameters.

Sahana *et al.* (2019) studied the influence of source and levels of fertilizers for fertigation in chrysanthemum variety 'Marigold'. The treatment T<sub>2</sub> containing 100 per cent of RDF i.e. 100:150:100 kg NPK per ha in the form of water soluble fertilizer (19:19:19, 12:61:00 and 00:00:50), along with liquid biofertilizer through fertigation recorded the maximum growth parameters such as plant height (42.64 cm), plant spread (38.68 cm), least days taken for first flowering (81 days), longest duration of flowering (125 days) and yield and flower quality parameters like maximum loose flower yield per hectare (27.94 t), cut flower yield per hectare (5.65 lakh), flower diameter (5.61 cm), shelf life of loose flowers (6.70 days) and cut flowers (11.50 days).

Nehra and Munendra (2019) studied the effect of different doses of nitrogen and potash fertilizers and plant spacing in chrysanthemum. Application of nitrogen at 160 kg/ha produced better plant growth over higher and lower doses including plant height, number of primary and secondary branches and dry matter accumulation in vegetative part which is the basis of better yield. Potash application was more effective at 180 kg/ha to show an increase in the plant growth parameters at all stages of growth. Plant spacing of 30-45 produced taller plants but spread of plants was more at 60-45 cm spacing.

Sanas *et al.* (2018) studies the effect of mulch, N and K application and their interaction on plant growth characters, yield and yield attributes of annual chrysanthemum (*Chrysanthemum coronarium* L). The result revealed that interaction effect of black plastic mulch + 40 g N + 30g P/m<sup>2</sup> recorded maximum growth, flowering and seed quality parameters of commercial importance.

Mahadik *et al.* (2017) investigated the effect of integrated system of plant nutrition management on growth, yield and flower quality of chrysanthemum cv. 'PDKV Ragini'. The maximum plant height, number of branches per plant, minimum days to first flower bud

initiation, opening of flower and 50 % flowering, whereas maximum flower heads per plant, flower yield per plant, diameter and shelf life of the flower was recorded with the application of biofertilizers and 50 % RDF (15:100:100 kg/ha of NPK) + 10 t/ha + VC (50 % N through VC).

Heidemann and Barbosa (2017) evaluate the production and quality of chrysanthemum varieties cultivated in pots with different NPK rates. The chrysanthemum varieties 'Shenna', 'Calabria' and 'Indianapolis' with the NPK rates (10-10-10) of 3g/l, 6g/l and 9 g/l. It was observed an inverse relation between the increase in NPK rate and cultivation cycle, resulting in precocity of flowering for all varieties. Plant cultivated under 9 g/l rate did not present toxicity symptoms, suggesting that this dose was more adequate for the production of pot plant for all three varieties.

Chandel *et al.* (2020) carried out an experiment on the treatment of azotobacter, phosphate solubilizing bacteria (PSB) and 75 % recommended dose of fertilizers (20 g N and 10 g  $P_2O_5/m^2$ ) on annual chrysanthemum. The results revealed that growth parameters such as maximum plant height (95.31 cm), plant spread (45.19 cm), flowering parameters such as minimum number of days taken for first flower opening (95.01 days), maximum number of flowers per plant (170.50), individual flower weight (2.30 g), duration of flowering (54.97 days) and yield parameters such as maximum flower yield per plant (490.80 g) were recorded in the plant. However, maximum flower size at the time of peak flowering (5.91 cm) was found in the plants supplied with azotobacter, PSB and 50 % RDF.

## ***Chapter-3***

# **MATERIALS AND METHODS**

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The present investigation entitled, “**Studies on the effect of N, P and K application at different stages in chrysanthemum (*Chrysanthemum morifolium* Ramat)**” was carried out at the experimental farm of the Department of Floriculture and Landscape Architecture, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during 2019-2020.

The details of experimental site, materials used and methodology adopted for carrying out the present study has been described in this chapter under the different sub heads as below:

### **3.1 EXPERIMENTAL SITE**

#### **3.1.1 Location**

The experimental farm of the department of Floriculture and Landscape Architecture is situated at an elevation of 1276 m above mean sea level at a latitude of 32°51'0" North and longitude of 77°11'30" East. The area falls under the mid zone of Himachal Pradesh.

#### **3.1.2 Climate**

The climate in general is sub-temperate to sub-tropical and is characterized by mild summer and cool dry winter. Maximum rainfall is received during July to September (Monsoon season). The mean monthly meteorological data pertaining to the period of investigation have been presented in Appendix-I.

#### **3.1.3 Soil status**

A basic study of the soil of the experimental field was conducted before starting the experiment. Soil samples were collected from the field up to a depth of 0-30 cm from randomly selected spots. The soil was analysed for various physicochemical properties like; pH, EC, organic carbon, available nitrogen, phosphorus and potassium. The details of the chemical analysis are furnished in Table 3.1.

**Table 3.1 Physico-chemical properties of the soil before planting**

| Physico-chemical property                    | Values obtained | Interpretation |
|----------------------------------------------|-----------------|----------------|
| Soil pH                                      | 6.91            | Normal         |
| Electrical Conductivity (dSm <sup>-1</sup> ) | 0.36            | Normal         |
| Organic Carbon (%)                           | 1.33            | High           |
| Available Nitrogen (kg/ha)                   | 341.48          | Medium         |
| Available Phosphorus (kg/ha)                 | 34.28           | High           |
| Available Potassium (kg/ha)                  | 261.00          | Medium         |

### **3.2 EXPERIMENTAL DETAILS**

#### **3.2.1 Plant material**

The investigation was conducted on two commercial cultivars of chrysanthemum namely; ‘Purnima’ (Plate 1A) and ‘Pusa Shwet’ (Plate 1B). Cultivar ‘Purnima’ is standard type whereas, ‘Pusa Shwet’ is a spray type. Both are white flowering cultivars. The plants of these cultivars were prepared through shoot tip cuttings. The shoot tip cuttings were rooted following below mentioned procedure.

#### **3.2.2 Procedure of propagation**

Shoot tip cutting of 8-10 cm length were taken from healthy and disease free mother plants. These cutting were dipped in a solution of Dithane M-45 (0.2%) plus Bavistin (0.1%) for half an hour. After dipping, basal leaves of each cutting were removed and given a sharp cut just below the basal node. The cut ends were then quick dipped in a solution of NAA (500 ppm) before planting of cutting for rooting in moist sand filled in the beds of propagation chamber. Just after planting, the beds were irrigated thoroughly. Thereafter, the cuttings were maintained under artificial misting till rooting. The cuttings took 20 to 25 days for rooting. Rooted cuttings were shifted to shade net house for hardening (Plate 1C). After 7-10 days in the hardening chamber these were transplanted in the field.

### **3.3 CULTIVATION PRACTICES**

#### **3.3.1 Bed preparation**

The land was thoroughly ploughed with power tiller and was brought to a fine tilth and finally levelled. Stones, pebbles and weeds were removed manually from the



**Plate 1A-Chrysanthemum  
cv. 'Purnima'**



**Plate 1B-Chrysanthemum  
cv. 'Pusa Shwet'**



**Plate 1C-Propagation of chrysanthemum through shoot tip cuttings**



**A. Vegetative stage**



**B. Flowering stage**

**Plate 2.View of the experimental trial**

experimental area. Raised beds of 1.0 m x 1.0 m were prepared for planting. The cross influence of treatments was 20 cm taken care by size separating each bed with a channel of 30 cm wide and 20 cm deep.

### **3.3.2 Application of Manures and Fertilizers**

Well decomposed FYM (farm yard manure) at the rate of 2 kg/m<sup>2</sup> was applied along with 20 g/m<sup>2</sup> of neem cake enriched with 0.1 g/m<sup>2</sup> of *Trichoderma harzianum* as a basal dose.

### **3.3.3 Planting**

Healthy, disease free and uniform sized rooted cuttings of the two cultivars, ‘Purnima’ and ‘Pusa Shwet’ were selected and transplanted on 19<sup>th</sup> June 2019. The cuttings were planted at a spacing of 30×30 cm from plant to plant and row to row accommodating 9 plants per meter square. Immediately after transplanting, light irrigation was done.

### **3.3.4 Irrigation**

Throughout the experimentation from planting till termination of the experiment, field was irrigated depending upon the requirement. Till the plants were fully established in the field, light irrigation was done both in the morning and evening hours. After the plants were established, irrigation was done depending upon the requirement.

### **3.3.5 Weeding and Hoeing**

Weeding was done manually with the help of hand hoe so as to keep the field neat and clean. The predominant weeds were *Capsella bursa-pastoris*, *Convolvulus arvensis*, *Oxalis latifolia*, *Stellaria media*, *Trifolium repens* and *Galinsoga parviflora*.

### **3.3.6 Pinching**

Pinching is an important operation which should be done carefully at appropriate time. The objective of pinching is to encourage the axillary branches and to increase the number of flowers. In order to produce multi-stemmed plants, pinching was done by removing 2-3 cm apical growing portion of the plant after 15 days of planting, leaving 6-8 leaves below the pinch.

### 3.3.7 Disbudding

It was done by removing the side buds and retaining the apical one on every shoot in case of 'Purnima' and vice versa in case of 'Pusa Shwet'.

### 3.3.8 Staking

Staking is necessary to keep plants erect and maintain proper shape of plants and bloom. Staking of individual plants was done just before flowering with the help of bamboo sticks in order to provide support to the plants.

### 3.3.9 Spray for Insect Pest and Diseases

The experiment was conducted under naturally ventilated polyhouse conditions. The insects which attacked the crop were aphids for which Imidacloprid (0.5ml/l) was sprayed. The larvae of *Helicoverpa armigera* also infested the crop at bud phase. Spray of Cypermethrin (1ml/l) was done at fortnightly intervals to control this pest.

The most serious disease which affected to chrysanthemum was septoria leaf spot caused by *Septoria obesa*. To avoid the spread of disease, removal of affected leaves was done. Apart from this, spray of Dithane M-45 @ 0.2% and Bavistin @ 0.1 % was done at 15 days interval.

## 3.4 EXPERIMENTAL DETAILS

The present study was conducted at the Experimental Farm of department of Floriculture and Landscape Architecture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (H.P). The details of the experiment were as follows:

**A. Cultivar** : Two ; namely

(i) Purnima

(ii) Pusa Shwet

**B. Nutritional treatments:** five (as given below).

**T<sub>1</sub>** : Recommended dose of fertilizer of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits- first as basal, second dose at pinching and third dose one month after pinching.

- T<sub>2</sub>** : 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase) @ 100:150:100 kg NPK/ha.
- T<sub>3</sub>** : 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75 kg NPK/ha.
- T<sub>4</sub>** : 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase) @ 75:112.5:75 kg NPK/ha.
- T<sub>5</sub>** : 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 100:150:100 kg NPK/ha.

In treatments T<sub>2</sub> to T<sub>5</sub>, 25% of fertilizers dose was applied as basal dose using straight fertilizer. Remaining 75% was applied as per the treatments details using water soluble fertilizers.

- C.** Total treatment combinations : 2×5=10
- D.** Replications : 3
- E.** Design : RBD (factorial with two levels of cultivar and 5 levels of nutritional treatments)

### **Methods of application of nutritional treatments:**

The required quantities of N, P and K per square meter were calculated from the recommended dose of fertilizers which varied with the treatment. Nitrogen, Phosphorus and Potassium were supplied through urea, SSP and MOP, respectively. Required quantity of these fertilizers was supplied as basal or both as basal and drench application depending upon the treatment. The required quantity of the nutrient per square meter was calculated by dividing the dose finalized for one hectare by 10,000. In this way the required quantity of the nutrients for T<sub>1</sub>, T<sub>2</sub> and T<sub>5</sub> were N-10g/m<sup>2</sup>, P-15 g/m<sup>2</sup> and K-10g/m<sup>2</sup>. However for treatments T<sub>3</sub> and T<sub>4</sub> the required quantities of nutrients were N-7.5 g/m<sup>2</sup>, P-11.25 g/m<sup>2</sup> and K-7.5 g/m<sup>2</sup>.

Treatment wise, the application of nutrients was done at different growth and flowering phases in different proportions following basal as well as drench methods of application. Drench application was done by dissolving the required quantity of fertilizer in 10 l of water per square meter. The details of the fertilizer and its quantity used at a particular phase was as given below in the Table 3.2

**Table 3.2 The details of the fertilizer and its quantity used at a particular phase in different treatments**

| <b>Treatments</b>    | <b>Name of the nutrient and quantity required (g/m<sup>2</sup>)</b> | <b>Fertilizer along with total quantity (g/m<sup>2</sup>) used</b> | <b>Method of application</b>                              | <b>Quantity of fertilizer used g/m<sup>2</sup></b> |
|----------------------|---------------------------------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------------------|----------------------------------------------------|
| <b>T<sub>1</sub></b> | N -10                                                               | Urea -21.74                                                        | Basal –in three equal splits<br>At the time of planting   | 7.25                                               |
|                      |                                                                     |                                                                    | Pinching                                                  | 7.25                                               |
|                      |                                                                     |                                                                    | One month after pinching                                  | 7.25                                               |
|                      | P -15                                                               | SSP -93.75                                                         | Basal - At the time of planting                           | 93.75                                              |
|                      | K -10                                                               | MOP -16.6                                                          | Basal - At the time of planting                           | 16.60                                              |
| <b>T<sub>2</sub></b> | N -10                                                               | Urea -21.74                                                        | Basal (25%)                                               | 5.44                                               |
|                      |                                                                     |                                                                    | Drench (75%)–in three splits<br>40% At vegetative phase   | 6.52                                               |
|                      |                                                                     |                                                                    | 30% At bud phase                                          | 4.89                                               |
|                      |                                                                     |                                                                    | 30% At flowering phase                                    | 4.89                                               |
|                      | P -15                                                               | SSP -93.75                                                         | Basal (25%)                                               | 23.45                                              |
|                      |                                                                     |                                                                    | Drench (75%)–in three splits<br>20% At vegetative phase   | 14.06                                              |
|                      |                                                                     |                                                                    | 40% At bud phase                                          | 28.12                                              |
|                      |                                                                     |                                                                    | 40% At flowering phase                                    | 28.12                                              |
|                      | K -10                                                               | MOP -16.60                                                         | Basal (25%)                                               | 4.15                                               |
|                      |                                                                     |                                                                    | Drench (75%)–in three splits<br>20% At vegetative phase   | 2.49                                               |
|                      |                                                                     |                                                                    | 40% At bud phase                                          | 4.98                                               |
|                      |                                                                     |                                                                    | 40% At flowering phase                                    | 4.98                                               |
| <b>T<sub>3</sub></b> | N -7.5                                                              | Urea -16.30                                                        | Basal (25%)                                               | 4.08                                               |
|                      |                                                                     |                                                                    | Drench (75%)–in three splits<br>33.3% At vegetative phase | 4.07                                               |
|                      |                                                                     |                                                                    | 33.3% At bud phase                                        | 4.07                                               |
|                      |                                                                     |                                                                    | 33.3% At flowering phase                                  | 4.07                                               |
|                      | P -11.25                                                            | SSP -70.31                                                         | Basal (25%)                                               | 17.58                                              |
|                      |                                                                     |                                                                    | Drench (75%)–in three splits<br>33.3% At vegetative phase | 17.58                                              |
|                      |                                                                     |                                                                    | 33.3% At bud phase                                        | 17.58                                              |
|                      |                                                                     |                                                                    | 33.3% At flowering phase                                  | 17.58                                              |
|                      | K -7.5                                                              | MOP -12.50                                                         | Basal (25%)                                               | 3.13                                               |
|                      |                                                                     |                                                                    | Drench (75%)–in three splits<br>33.3% At vegetative phase | 3.12                                               |
|                      |                                                                     |                                                                    | 33.3% At bud phase                                        | 3.12                                               |
|                      |                                                                     |                                                                    | 33.3% At flowering phase                                  | 3.12                                               |
|                      | N -7.5                                                              | Urea -16.30                                                        | Basal (25%)                                               | 4.07                                               |
|                      |                                                                     |                                                                    | Drench (75%)–in three splits<br>40% At vegetative phase   | 4.89                                               |
|                      |                                                                     |                                                                    | 30% At bud phase                                          | 3.67                                               |
|                      |                                                                     |                                                                    | 30% At flowering phase                                    | 3.67                                               |

|                      |          |             |                                                           |       |
|----------------------|----------|-------------|-----------------------------------------------------------|-------|
| <b>T<sub>4</sub></b> | P -11.25 | SSP -70.31  | Basal (25%)                                               | 17.58 |
|                      |          |             | Drench (75%)–in three splits<br>20% At vegetative phase   | 10.55 |
|                      |          |             | 40% At bud phase                                          | 21.09 |
|                      |          |             | 40% At flowering phase                                    | 21.09 |
|                      | K -7.5   | MOP -12.5   | Basal (25%)                                               | 3.13  |
|                      |          |             | Drench (75%)–in three splits<br>20% At vegetative phase   | 1.87  |
|                      |          |             | 40% At bud phase                                          | 3.75  |
|                      |          |             | 40% At flowering phase                                    | 3.75  |
| <b>T<sub>5</sub></b> | N -10    | Urea -21.73 | Basal (25%)                                               | 5.44  |
|                      |          |             | Drench (75%)–in three splits<br>33.3% At vegetative phase | 5.43  |
|                      |          |             | 33.3% At bud phase                                        | 5.43  |
|                      |          |             | 33.3% At flowering phase                                  | 5.43  |
|                      | P -15    | SSP -93.75  | Basal (25%)                                               | 23.44 |
|                      |          |             | Drench (75%)–in three splits<br>33.3% At vegetative phase | 23.44 |
|                      |          |             | 33.3% At bud phase                                        | 23.44 |
|                      |          |             | 33.3% At flowering phase                                  | 23.44 |
|                      | K -10    | MOP -16.67  | Basal (25%)                                               | 4.17  |
|                      |          |             | Drench (75%)–in three splits<br>33.3% At vegetative phase | 4.17  |
|                      |          |             | 33.3% At bud phase                                        | 4.17  |
|                      |          |             | 33.3% At flowering phase                                  | 4.17  |

#### Observations recorded:

##### 1. Plant height (cm)

Plant height was recorded at the harvesting stage of cut stems. It was recorded from the base of the plant to the base of the apical flower to the tallest shoot.

##### 2. Plant spread (cm)

It was also measured at the harvesting stage of flowers as average of the distance between outermost shoot in East to West and the distance between the outermost shoot in the North to South direction.

##### 3. Number of days taken for flower bud appearance

Number of days taken for flower bud appearance was counted from the date of transplanting to the stage when first flower bud appeared.

**4. Number of days taken for flower bud opening**

Days taken for first flower bud opening were counted from date of transplanting to the opening of the first flower bud on a plant.

**5. Number of days taken to flowering**

Days taken to flowering were recorded from the date of planting to the stage when 50-60 per cent buds were fully opened.

**6. Flower diameter (cm)**

Flower diameter was counted at the time of peak flowering as average of the distance between apices of petals in East to West direction and distance between apices of petals in North to South direction.

**7. Number of shoots per plant**

Number of shoots per plant was counted at the time of peak flowering.

**8. Weight of flowers per plant (g)**

Weight of cut flower stems was recorded at the time of harvesting stage.

**9. Duration of flowering (days)**

The days were counted from opening of first flower to fading of last flower.

**10. Vase life (days)**

Vase life was counted from date of placing flowers in the vase to the stage till they remain presentable.

**11. Available soil NPK (kg/ha) initial and final**

The composite soil samples were collected at 0-15 cm depth from each plot and analysed for physico-chemical properties.

**12. Cost of cultivation (B:C ratio)**

It was calculated by taking into account the cost of land preparation, planting, intercultural operations, material inputs, intercultural operations expenses with the labour charge as Rs 300/manday. It was calculated by the following

Formula:

$$\text{Benefit Cost Ratio} = \frac{\text{Gross return}}{\text{Total expenditure}}$$

Net returns were calculated as follows:

$$\text{Net returns} = \text{Gross monetary returns} - \text{Total cost of production}$$

### 13. Number of suckers produced per plant

It was recorded by counting the planting size suckers in the months of February.

### Statistical Analysis

The data recorded was analysed by using MS-Excel and OPSTAT. The statistical analysis for Randomized Block Design was done as per design of the experiment suggested by Gomez and Gomez (1984).

### ANOVA for RBD

| Source of variance | Degree of freedom                    | Sum of squares | Mean sum of squares                                    | F <sub>cal</sub>  |
|--------------------|--------------------------------------|----------------|--------------------------------------------------------|-------------------|
| Treatments         | (t-1)                                | S <sub>t</sub> | $M_t = \frac{S_t}{(t-1)}$                              | $\frac{M_t}{M_e}$ |
| Replications       | (r-1)                                | S <sub>r</sub> | $M_r = \frac{S_r}{(r-1)}$                              | $\frac{M_r}{M_e}$ |
| Error              | $(\frac{r}{t} - 1)(\frac{t}{r} - 1)$ | S <sub>e</sub> | $M_e = \frac{S_e}{(\frac{r}{t} - 1)(\frac{t}{r} - 1)}$ |                   |
| Total              | $(\frac{r}{t} - 1)(\frac{t}{r} - 1)$ | S <sub>T</sub> |                                                        |                   |

where,

- r = Number of replications
- t = Number of treatments
- S<sub>r</sub> = Sum of squares due to replications
- S<sub>t</sub> = Sum of squares due to treatments
- S<sub>e</sub> = Sum of squares due to error
- S<sub>T</sub> = Total sum of squares
- M<sub>r</sub> = Mean sum of squares due to replications
- M<sub>t</sub> = Mean sum of squares due to treatments
- M<sub>e</sub> = Mean sum of squares due to error

The replication and treatment mean sum of square was tested against mean sum of squares due to error by 'F' test at (r-1), (r-1) × (t-1) and (t-1), (r-1) × (t-1) degree of freedom

for RBD at 5% level of significance. The calculated F-values will be compared with tabulated F-value. When F-test will be found significant, critical difference was calculated to find out the superiority of one treatment over the others.

**Critical difference (CD) will be calculated as follows:**

$$CD_{0.05} = S.E. (d) \times t_{(0.05)} (r-1) (t-1) df$$

$$SE (d) \pm = \sqrt{\frac{2 \times M_e}{r}}$$

$$SE (m) \pm = \sqrt{\frac{M_e}{r}}$$

where,

$$CD_{0.05} = \text{Critical difference at 5 per cent level of significance}$$

$$SE (d) \pm = \text{Standard error of difference of mean}$$

$$SE (m) \pm = \text{Standard error of mean}$$

### 3.5 ANALYSIS OF SOIL FOR NPK, pH, EC AND ORGANIC CARBON CONTENT

#### (i) Available Nitrogen (Subbiah and Asija, 1956).

Five gram of soil was moistened with 2ml distilled water and was added to Kjeldahl distillation flask. 25 ml of 0.32 per cent  $KMnO_4$  and 25 ml of 2.5 per cent NaOH solution were added to the assembly and the cork was fitted immediately. 20 ml of 0.02N  $H_2SO_4$  was taken in a conical flask and to it 3 drops of methyl red indicator was added to it. Hot plate/heater was switched on to distill ammonia gas and 30 ml flask of distillate in 0.02N  $H_2SO_4$  was collected. The excess of  $H_2SO_4$  in the conical flask was titrated against 0.02N NaOH and the change in colour from pink to yellow was noted as the end point.

$$\text{Available Nitrogen percentage} = \frac{(10-A) \times 0.00028}{\text{Weight of soil (g)}} \times 100$$

Where,

A = Volume of 0.02N NaOH used

ppm of available N in soil = Available Nitrogen percentage x 10,000

Available Nitrogen kg/ha = ppm x 2.24

**(ii) Available Phosphorous (Olsen's *et al.*, 1954)**

One gram of soil was taken in a conical flask and a pinch of Darco-G 60 and 20 ml of 0.5N Sodium bicarbonate was added to it. The contents were shaken for 30 minutes and thereafter filtered to obtain a clear filtrate. To 5 ml of the filtrate, 5 ml of ammonium molybdate was added. The mixture was thoroughly shaken to remove the CO<sub>2</sub> evolved. Then the contents of the flask were diluted to about 20 ml. One ml of working solution of SnCl<sub>2</sub> was added and its volume was made to 25 ml in the volumetric flask. The contents were mixed thoroughly and the blue colour intensity was measured with colorimeter after 5 minutes at 660 nm. An appropriate blank was also run simultaneously.

$$\text{ppm of available P in soil} = A \times \text{Total dilution}$$

Where,

A = Concentration of P as read from the standard curve.

$$\text{Available Phosphorous (kg/ha)} = \text{ppm} \times 2.24$$

**(iii) Available Potassium (Merwin and Peech, 1951)**

Available potassium was extracted with neutral normal ammonium acetate, after shaking 5 g of soil sample in 25 ml of extractant for 5 minutes and then filtered. Volume of the filtrate was made up to 100 ml and available K was determined on flame photometer. The flame photometer was standardized by feeding a standard solution of known concentration prepared by using KCl. The standard curve was prepared by the standard fed to the equipment and reading of the test sample was extrapolated.

$$\text{ppm of available K in sample} = Y \times \text{Total dilution}$$

Where,

Y = ppm as read from the standard curve

$$\text{Available Potassium kg/ha} = \text{ppm} \times 2.24$$

**(iv) Soil pH**

pH was determined in soil, water ratio water 1:2 by a pH meter as described by Jackson (1973). 20 g of the soil sample was taken in a 50 ml beaker and 40 ml of the distilled water was added to it. The beaker was stirred at least four times within a period of half an

hour. This time is required for the soil and water to attain equilibrium. After half an hour, again the soil suspension was stirred and pH measured on a digital pH-meter.

**(v) Soil Electrical conductivity (dS/m)**

20 g of the soil sample was taken in a 50 ml beaker and 40 ml of the distilled water was added to it. The beaker was stirred intermittently 4-5 times and left overnight for getting a clear supernatant solution. The Electrical conductivity (EC) of the supernatant solution was measured by Systronic's conductivity meter and was expressed in  $\text{dSm}^{-1}$  (Jackson, 1973).

**(vi) Soil organic carbon content (%)**

Organic carbon of the soil sample was determined by chromic acid titration method of Walkley and Black (1934).

## Chapter -4

# RESULTS AND DISCUSSION

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The observations recorded on various aspects of the “**Studies on effect of N, P and K application at different stages in chrysanthemum (*Chrysanthemum morifolium* Ramat)**” are presented in this chapter. The ANOVA for various studied parameters have been presented in Appendix – II.

The studies were conducted on two cultivars namely; ‘Purnima’ (standard type) and ‘Pusa Shwet’ (spray type) to find out the effect of phenophase based application of N, P and K on cut flower production. Character-wise results of the experiment conducted under naturally ventilated polyhouse are presented below:

### 4.1 PLANT HEIGHT (cm)

Data pertaining to plant height of two cultivars of chrysanthemum namely; ‘Purnima’ and ‘Pusa Shwet’ is presented in Table 4.1. Plant height was recorded at the time of peak flowering. Variations in plant height due to cultivars, nutritional treatments and their interaction were found to be significant.

Perusal of data revealed more plant height in case of cultivar ‘Pusa Shwet’ (69.76 cm) as compared to ‘Purnima’ (42.49 cm).

Among different nutritional treatments, basal application of 75:112.5:75 kg NPK/ha (T<sub>4</sub>) in different proportions as 40:20:20 per cent during vegetative phase, 30:40:40 per cent during bud phase and 30:40:40 per cent during flowering phase, resulted in maximum plant height (57.87 cm). Other treatments, T<sub>3</sub> and T<sub>1</sub> (57.33 cm and 56.78 cm, respectively) were also found to be at par with T<sub>4</sub>. In contrast, minimum plant height (52.52 cm) was recorded with T<sub>2</sub> i.e. 40:20:20 per cent NPK (Vegetative phase), 30:40:40 per cent NPK (Bud phase), 30:40:40 per cent NPK (Flowering phase) of 100:150:100 kg NPK /ha.

Interaction between cultivars and nutritional treatments, revealed maximum plant height with T<sub>3</sub> in the cultivar ‘Pusa Shwet’ (73.35 cm) which was statistically at par with nutritional treatment T<sub>1</sub> (71.57 cm) in the same cultivar. However, minimum plant height was noted with T<sub>2</sub> in cultivar ‘Purnima’ (38.07 cm).

**Table 4.1 Effect of phenophase based application of nutritional treatments on plant height (cm) of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima      | Pusa Shwet   | Mean  |
|------------------------|--------------|--------------|-------|
| *T <sub>1</sub>        | 41.99        | 71.57        | 56.78 |
| T <sub>2</sub>         | 38.07        | 66.97        | 52.52 |
| T <sub>3</sub>         | 41.31        | 73.35        | 57.33 |
| T <sub>4</sub>         | 47.63        | 68.10        | 57.87 |
| T <sub>5</sub>         | 43.46        | 68.83        | 56.15 |
| <b>Mean</b>            | <b>42.49</b> | <b>69.76</b> | ----- |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

**CD<sub>0.05</sub> for:**

|                                    |        |
|------------------------------------|--------|
| Cultivars                          | : 0.98 |
| Nutritional treatments             | : 1.55 |
| Cultivars X Nutritional treatments | : 2.19 |

Availability of NPK in the growing medium and their uptake is very important for plant growth. It is well known that nitrogen increases transport of metabolites and rate of photosynthesis in plants, which enables the plant to have quick and better upward vegetative growth. Similar findings have also been reported by Barman and Pal (1999), Chawla *et al.* (2007) and Ahmed *et al.* (2017), showing maximum plant height by the application of nitrogen and potash in chrysanthemum. Phosphorus, being constituent of nucleoprotein, plays a leading role in photosynthesis, cell division and tissue formation (Arnon, 1959), thereby helps in increasing plant height. Potassium is involved in the meristematic growth of the plant. Beneficial effects of potash on the growth of plants have been reported by Gurav *et al.* (2002) in gerbera. The response of NPK in the present case when applied based on phenophases varied with the cultivar for plant height as in case of ‘Purnima’ (47.63 cm), T<sub>4</sub> was found best while ‘Pusa Shwet’ (73.35 cm) showed maximum plant height with the application of T<sub>3</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

## 4.2 PLANT SPREAD (cm)

Data pertaining to plant spread of two cultivars of chrysanthemum namely; ‘Purnima’ and ‘Pusa Shwet’ is presented in Table 4.2. Variations in plant spread due to cultivars, nutritional treatments and their interaction were found to be significant.

Perusal of data revealed more plant spread in case of cultivar ‘Pusa Shwet’ (27.97 cm) as compared to ‘Purnima’ (24.06 cm).

Among different nutritional treatments, basal application of 75:112.5:75 kg NPK/ha (T<sub>4</sub>) in different proportions as 40:20:20 per cent during vegetative phase, 30:40:40 per cent during bud phase and 30:40:40 per cent during flowering phase, resulted in maximum plant spread (27.55 cm). Other treatments, T<sub>3</sub> and T<sub>5</sub> (26.71 cm and 26.20 cm, respectively) were also found to be at par with T<sub>4</sub>. In contrast, minimum plant spread (24.53 cm) was recorded with T<sub>2</sub> i.e. 40:20:20 per cent NPK (Vegetative phase), 30:40:40 per cent NPK (Bud phase), 30:40:40 per cent NPK (Flowering phase) of 100:150:100 kg NPK/ha which was found to be at par with nutritional treatments T<sub>1</sub> and T<sub>5</sub> (25.08 cm and 26.20 cm, respectively).

**Table 4.2 Effect of phenophase based application of nutritional treatments on plant spread (cm) of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima      | Pusa Shwet   | Mean         |
|------------------------|--------------|--------------|--------------|
| *T <sub>1</sub>        | 22.10        | 28.07        | <b>25.08</b> |
| T <sub>2</sub>         | 22.82        | 26.25        | <b>24.53</b> |
| T <sub>3</sub>         | 24.89        | 28.52        | <b>26.71</b> |
| T <sub>4</sub>         | 27.93        | 27.16        | <b>27.55</b> |
| T <sub>5</sub>         | 22.57        | 29.83        | <b>26.20</b> |
| <b>Mean</b>            | <b>24.06</b> | <b>27.97</b> | -----        |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

**CD<sub>0.05</sub> for:**

|                                    |        |
|------------------------------------|--------|
| Cultivars                          | : 1.25 |
| Nutritional treatments             | : 1.97 |
| Cultivars X Nutritional treatments | : 2.79 |

Interaction between cultivars and nutritional treatments, revealed maximum plant spread with T<sub>5</sub> in the cultivar ‘Pusa Shwet’ (29.83 cm) which was statistically at par with nutritional treatment T<sub>3</sub>, T<sub>1</sub> and T<sub>4</sub> (28.52 cm, 28.07 cm and 27.16 cm, respectively) in the same cultivar. However, minimum plant spread was noted with T<sub>1</sub> in cultivar ‘Purnima’ (22.10 cm) which was statistically at par with nutritional treatments T<sub>5</sub> and T<sub>2</sub> (22.57 cm and 22.82 cm, respectively) in the same cultivar.

Availability of NPK in the growing medium and their uptake is very important for plant growth. It is known that nitrogen enhances plant spread as nitrogen is the constituent of protein and nucleic acid and is helpful in promoting plant growth. These results are in close conformity with the findings of Haque and Jakhro (2001) and Rajan *et al.* (2019) in chrysanthemum. Increase in plant spread by phosphorous application might result from phosphorous acting as a constituent of nucleoprotein, which in effect plays a leading role in photosynthesis, cell division and tissue formation. Similar results have been reported by Dorajeerao *et al.* (2012). Increase in plant spread also may be due to genotypic differences between them. The application of potassium fertilization also helps to increase plant spread which may be attributed to the stimulating effect of potassium on photosynthesis, phloem loading and carbohydrate translocation as well as synthesis of large molecular weight substances. The response of NPK in the present case when applied based on phenophases varied with the cultivar for plant spread as in case of ‘Purnima’ (27.93 cm), T<sub>4</sub> was found best while ‘Pusa Shwet’ (29.83 cm) showed maximum plant spread with the application of T<sub>5</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

#### **4.3 NUMBER OF DAYS TAKEN FOR FLOWER BUD APPEARANCE (days)**

Data pertaining to number of days taken for flower bud appearance of two cultivars of chrysanthemum namely; ‘Purnima’ and ‘Pusa Shwet’ is presented in Table 4.3. Variation in number of days taken for flower bud appearance due to cultivars was found to be significant. However, nutritional treatments and their interactions were found to be non-significant.

Scrutiny of data revealed less number of days taken for flower bud appearance in case of cultivar ‘Purnima’ (92.49 days) as compared to ‘Pusa Shwet’ (105.80 days).

Among different nutritional treatments, application of 75:112.5:75 kg NPK/ha (T<sub>4</sub>) in different proportions as 40:20:20 per cent during vegetative phase, 30:40:40 per cent during

bud phase and 30:40:40 per cent during flowering phase, resulted in minimum number of days taken for flower bud appearance (97.92 days). In contrast, maximum number of days taken for flower bud appearance with (100.28 days) was recorded with T<sub>1</sub> i.e. 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching.

**Table 4.3 Effect of phenophase based application of nutritional treatments on number of days taken for flower bud appearance (days) of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima      | Pusa Shwet    | Mean          |
|------------------------|--------------|---------------|---------------|
| *T <sub>1</sub>        | 94.23        | 106.33        | <b>100.28</b> |
| T <sub>2</sub>         | 91.80        | 106.33        | <b>99.07</b>  |
| T <sub>3</sub>         | 94.63        | 105.00        | <b>99.82</b>  |
| T <sub>4</sub>         | 90.17        | 105.67        | <b>97.92</b>  |
| T <sub>5</sub>         | 91.60        | 105.67        | <b>98.63</b>  |
| <b>Mean</b>            | <b>92.49</b> | <b>105.80</b> | -----         |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

**CD<sub>0.05</sub> for:**

|                                    |        |
|------------------------------------|--------|
| Cultivars                          | : 1.20 |
| Nutritional treatments             | : NS   |
| Cultivars X Nutritional treatments | : NS   |

Interaction between cultivars and nutritional treatments, revealed minimum number of days taken for bud appearance with T<sub>4</sub> in the cultivar ‘Purnima’ (90.17 days). However, maximum number of days taken for bud appearance was noted with T<sub>1</sub> and T<sub>2</sub> in the cultivar ‘Pusa Shwet’ (106.33 days).

Availability of NPK in the growing medium and their uptake is very important for plant growth. Nitrogen delayed the initiation of flower bud appearance generally due to the prolonged vegetative phase because nitrogen has synergistic effect (Sheoran *et al.*, 2016). These results are in agreement with the findings of Kumar *et al.* (2002) in tuberose cv. ‘Single’. Early appearance of flower bud due to phosphorus might be attributed to rapid vegetative growth. Similar finding was also reported by Kumar and Shanmugavella (1978).

Potassium helps to maintain a normal balance between carbohydrates and proteins resulting in minimum flower bud appearance. Similar result was reported by Nayak *et al.* (2005) in gerbera. The response of NPK in the present case when applied based on phenophases varied with the cultivar for flower bud appearance as in case of ‘Purnima’ (90.17 days), T<sub>4</sub> was found best while ‘Pusa Shwet’ (105.00 days) showed minimum days to flower bud appearance with the application of T<sub>3</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

#### 4.4 NUMBER OF DAYS TAKEN FOR FLOWER BUD OPENING (days)

Data pertaining to number of days taken for flower bud opening of two cultivars of chrysanthemum namely; ‘Purnima’ and ‘Pusa Shwet’ is presented in Table 4.4. Variation in number of days taken for flower bud opening due to cultivars and their interaction were found to be significant. However, nutritional treatments were found to be non-significant.

Perusal of data revealed less number of days taken for flower bud opening in case of cultivar ‘Purnima’ (127.61 days) as compared to ‘Pusa Shwet’ (136.33 days).

**Table 4.4 Effect of phenophase based application of nutritional treatments on number of days taken for flower bud opening (days) of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima       | Pusa Shwet    | Mean          |
|------------------------|---------------|---------------|---------------|
| *T <sub>1</sub>        | 125.67        | 134.00        | <b>129.83</b> |
| T <sub>2</sub>         | 129.93        | 134.00        | <b>131.97</b> |
| T <sub>3</sub>         | 129.67        | 134.00        | <b>131.83</b> |
| T <sub>4</sub>         | 126.73        | 140.00        | <b>133.37</b> |
| T <sub>5</sub>         | 126.07        | 139.67        | <b>132.87</b> |
| <b>Mean</b>            | <b>127.61</b> | <b>136.33</b> | -----         |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

**CD<sub>0.05</sub> for:**

|                                    |        |
|------------------------------------|--------|
| Cultivars                          | : 2.32 |
| Nutritional treatments             | : NS   |
| Cultivars X Nutritional treatments | : 5.18 |

Among different nutritional treatments, basal application of 100:150:100 kg NPK/ha T<sub>1</sub> in different proportions as full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching, resulted in minimum number of days taken for flower bud opening (129.83 days). In contrast, maximum number of days taken for flower bud opening (133.37 days) was recorded with T<sub>4</sub> i.e. 40:20:20 per cent NPK (Vegetative phase), 30:40:40 per cent NPK (Bud phase), 30:40:40 per cent NPK (Flowering phase) of 75:112.5:75 kg NPK/ha.

Interaction between cultivars and nutritional treatments, revealed minimum number of days taken for flower bud opening with T<sub>1</sub> in the cultivar 'Purnima' (125.67 days) which was statistically at par all the with nutritional treatments T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub> and T<sub>2</sub> (126.07 days, 126.73 days, 129.67 days and 129.93 days, respectively). However, maximum number of days taken for flower bud opening was noted with T<sub>4</sub> in the cultivar 'Pusa Shwet' (140.00 days) which was statistically at par with nutritional treatment T<sub>5</sub> (139.67 days) in the same cultivar.

Availability of NPK in the growing medium and their uptake is very important for plant growth. Nitrogen may have caused excessive vegetative growth adversely affecting days taken to flower bud opening. Similar finding was reported by Gowda *et al.* (1991), Sharma and Singh (2001) and Rani *et al.* (2005). Plants receiving treatment T<sub>4</sub> in the cultivar 'Purnima' was earlier in bud formation which might be due to low phosphorus application. Similar results also recorded by Mohanty *et al.* (2002) in marigold. Flowering character have been influenced significantly with potassium application. Plant with treatment T<sub>4</sub> took more days for flower bud opening which might be due to more potassium application. Similar results have been reported by Chanda *et al.* (2000). The response of NPK in the present case when applied based on phenophases varied with the cultivar for flower bud opening as in case of 'Purnima' (125.67 days), T<sub>1</sub> was found best while 'Pusa Shwet' (134.00 days) showed minimum days to flower bud opening with the application of T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

#### **4.5 DAYS TAKEN TO FLOWERING (days)**

Data pertaining to number of days taken to flowering of two cultivars of chrysanthemum namely; 'Purnima' and 'Pusa Shwet' is presented in Table 4.5. Variation in

number of days taken to flowering due to cultivars, and their interaction were found to be significant. However, nutritional treatments were found to be non-significant.

Perusal of data revealed less number of days taken to flowering in case of cultivar ‘Purnima’ (132.49 days) as compared to ‘Pusa Shwet’ (151.73 days).

Among different nutritional treatments, basal application of 75:112.5:75 kg NPK/ha T<sub>4</sub> in different proportions as 40:20:20 per cent during vegetative phase, 30:40:40 per cent during bud phase and 30:40:40 per cent during flowering phase of 75:112.5:75 kg NPK/ha, resulted in minimum number of days to flowering (140.91 days). In contrast, maximum number of days taken to flowering (143.28 days) was recorded with T<sub>1</sub> i.e. 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching.

**Table 4.5 Effect of phenophase based application of nutritional treatments on number of days taken to flowering (days) of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima       | Pusa Shwet    | Mean          |
|------------------------|---------------|---------------|---------------|
| *T <sub>1</sub>        | 134.23        | 152.33        | <b>143.28</b> |
| T <sub>2</sub>         | 131.80        | 152.33        | <b>142.07</b> |
| T <sub>3</sub>         | 134.63        | 150.67        | <b>142.65</b> |
| T <sub>4</sub>         | 130.17        | 151.67        | <b>140.91</b> |
| T <sub>5</sub>         | 131.60        | 151.67        | <b>141.63</b> |
| <b>Mean</b>            | <b>132.49</b> | <b>151.73</b> | <b>-----</b>  |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

**CD<sub>0.05</sub> for:**

|                                    |        |
|------------------------------------|--------|
| Cultivars                          | : 1.16 |
| Nutritional treatments             | : NS   |
| Cultivars X Nutritional treatments | : 2.60 |

Interaction between cultivars and nutritional treatments, revealed minimum number of days taken to flowering with T<sub>4</sub> in the cultivar ‘Purnima’ (130.17 days) which was statistically at par with nutritional treatments T<sub>5</sub> and T<sub>2</sub> (131.60 days and 131.80 days, respectively). However, maximum number of days taken to flowering was noted with T<sub>1</sub> and

T<sub>2</sub> in the cultivar 'Pusa Shwet' (152.33 days) which was statistically at par with nutritional treatment T<sub>4</sub>, T<sub>5</sub> and T<sub>3</sub> (151.67 days, 151.67 days and 150.67 days) in the same cultivar.

Availability of NPK in the growing medium and their uptake is very important for plant growth. Earliest flowering through the application of nitrogen might be due to the fact that nitrogen produced vigorous plant and resulted into the production of more photosynthates that are responsible for flowering. Similar finding was observed by Kumar and Shanmugavella (1978), who found that the increase in nitrogen level stimulated early flowering in chrysanthemum. Plant with treatment T<sub>1</sub> took more days to flowering which might be due to the fact that high phosphorus application during vegetative phase have kept the plants in vegetative phase for longer period which result in delayed flowering, this results are in close conformity with the findings of Mohanty *et al.* (2002) in marigold. Potassium is required to increase carbon exchange and enhance carbohydrate movement (Collins and Duke, 1981) thereby early initiation of flowering. The response of NPK in the present case when applied based on phenophases varied with the cultivar for number of days taken to flowering as in case of 'Purnima' (130.17 days), T<sub>4</sub> was found best while 'Pusa Shwet' (150.67 days) showed minimum flower bud appearance with the application of T<sub>3</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

#### **4.6 FLOWER DIAMETER (cm)**

Data pertaining to flower diameter of two cultivars of chrysanthemum namely; 'Purnima' and 'Pusa Shwet' is presented in Table 4.6. Variation in flower diameter due to cultivars was found to be significant. However, nutritional treatment and their interaction were found to be non-significant.

Perusal of data revealed more flower diameter in case of cultivar 'Purnima' (10.12 cm) as compared to 'Pusa Shwet' (6.90 cm).

Among different nutritional treatments, basal application of 100:150:100 kg NPK/ha (T<sub>2</sub>) in different proportions as 40:20:20 per cent during vegetative phase, 30:40:40 per cent during bud stage and 30:40:40 per cent during flowering phase, resulted in maximum flower diameter (8.87 cm). In contrast, minimum flower diameter (8.19 cm) was recorded with T<sub>4</sub> i.e. 40:20:20 per cent NPK (Vegetative phase), 30:40:40 per cent NPK (Bud phase), 30:40:40 per cent NPK (Flowering phase) of 75:112.5:75 kg NPK /ha.

**Table 4.6 Effect of phenophase based application of nutritional treatments on flower diameter (cm) of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima      | Pusa Shwet  | Mean         |
|------------------------|--------------|-------------|--------------|
| *T <sub>1</sub>        | 9.95         | 6.97        | <b>8.46</b>  |
| T <sub>2</sub>         | 9.77         | 7.98        | <b>8.87</b>  |
| T <sub>3</sub>         | 10.37        | 6.60        | <b>8.49</b>  |
| T <sub>4</sub>         | 9.95         | 6.43        | <b>8.19</b>  |
| T <sub>5</sub>         | 10.57        | 6.50        | <b>8.53</b>  |
| <b>Mean</b>            | <b>10.12</b> | <b>6.90</b> | <b>-----</b> |

**\*T<sub>1</sub>:** Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. **T<sub>2</sub>:** 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. **T<sub>3</sub>:** 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. **T<sub>4</sub>:** 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. **T<sub>5</sub>:** 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

**CD<sub>0.05</sub> for:**

|                                    |        |
|------------------------------------|--------|
| Cultivars                          | : 0.61 |
| Nutritional treatments             | : NS   |
| Cultivars X Nutritional treatments | : NS   |

Interaction between cultivars and nutritional treatments, revealed maximum flower diameter with T<sub>5</sub> in the cultivar ‘Purnima’ (10.57 cm). However, minimum flower diameter was noted in T<sub>4</sub> in cultivar ‘Purnima’ (6.43 cm).

Availability of NPK in the growing medium and their uptake is very important for plant growth. The increase in the size of flower due to nitrogen may be contributed by meristematic activity of metabolites from vegetative growth of plants. Beneficial effect of nitrogen application on the flower sizes have also been reported by Agrawal *et al.* (2002) in marigold. Phosphorus resulted in maximum increase in nutrient uptake and stimulates blooming, resulting in maximum flower diameter. Similar results have been reported by Mohariya *et al.* (2004). Potassium increased flower diameter as it helps to improve efficiency of photosynthesis, thereby helps in increasing flower size. The response of NPK in the present case when applied based on phenophases varied with the cultivar for flower diameter as in case of ‘Purnima’ (10.57 cm), T<sub>5</sub> was found best while ‘Pusa Shwet’ (7.98 cm) showed maximum flower diameter with the application of T<sub>2</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

#### 4.7 NUMBER OF SHOOTS PER PLANT

Data pertaining to number of shoots per plant of two cultivars of chrysanthemum namely; ‘Purnima’ and ‘Pusa Shwet’ is presented in Table 4.7. Variation in number of shoots per plant due to cultivars was found to be significant. However, nutritional treatments and their interactions were found to be non-significant.

Perusal of data revealed more number of shoots per plant in case of cultivar ‘Pusa Shwet’ (4.09) as compared to ‘Purnima’ noted (2.44).

**Table 4.7 Effect of phenophase based application of nutritional treatments on number of shoots per plant of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima     | Pusa Shwet  | Mean        |
|------------------------|-------------|-------------|-------------|
| *T <sub>1</sub>        | 2.43        | 3.57        | <b>3.00</b> |
| T <sub>2</sub>         | 2.40        | 3.77        | <b>3.08</b> |
| T <sub>3</sub>         | 2.13        | 4.00        | <b>3.07</b> |
| T <sub>4</sub>         | 2.30        | 4.63        | <b>3.47</b> |
| T <sub>5</sub>         | 2.93        | 4.50        | <b>3.72</b> |
| <b>Mean</b>            | <b>2.44</b> | <b>4.09</b> | -----       |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

#### CD<sub>0.05</sub> for:

|                                    |        |
|------------------------------------|--------|
| Cultivars                          | : 0.57 |
| Nutritional treatments             | : NS   |
| Cultivars X Nutritional treatments | : NS   |

Among different nutritional treatments, basal application of 100:150:100 kg NPK/ha (T<sub>5</sub>) applied in different proportions as 33.3:33.3:33.3 per cent during vegetative phase, 33.3:33.3:33.3 per cent during bud phase and 33.3:33.3:33.3 per cent during flowering phase, resulted in maximum number of shoots per plant (3.72). In contrast, minimum number of shoots per plant (3.00) was recorded with T<sub>1</sub> i.e. 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching.

Interaction between cultivars and nutritional treatments, revealed maximum number of shoots per plant with T<sub>4</sub> in the cultivar ‘Pusa Shwet’ (4.63). However, minimum number of shoots per plant was noted with T<sub>3</sub> in the cultivar ‘Purnima’ (2.13).

Availability of NPK in the growing medium and their uptake is very important for plant growth. The increased number of shoots per plant is due to the fact that applied nitrogen had significantly increased the growth parameters, which might have synthesized more plant metabolites and ultimately led to increased production of shoots. Similar findings were also reported by Chawla *et al.* (2007), Patel and Chaudhari (2011) and Joshi *et al.* (2013) in chrysanthemum. Number of shoot per plant was increased with the application of phosphorus might be due to improvement in various vegetative parameters. The similar findings were also reported by Chawla *et al.* (2007) and Joshi *et al.* (2013) in chrysanthemum. Potassium showed to have an impact on the plant growth and development as it improved plant vigour, vegetative growth and increased number of shoot per plant. The response of NPK in the present case when applied based on phenophases varied with the cultivar for number of shoots per plant as in case of 'Purnima' (2.93), T<sub>5</sub> was found best while 'Pusa Shwet' (4.63) showed maximum number of shoots per plant with the application of T<sub>4</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

#### **4.8 WEIGHT OF FLOWERS PER PLANT (g)**

Data pertaining to weight of flowers per plant of two cultivars of chrysanthemum namely; 'Purnima' and 'Pusa Shwet' is presented in Table 4.8. Variation in weight of flowers per plant due to cultivars and nutritional treatments were found to be significant. However, their interaction was found to be non-significant.

Perusal of data revealed more weight of flowers per plant in case of cultivar 'Pusa Shwet' (70.81 g) as compared to 'Purnima' (21.42 g).

Among different nutritional treatments, application of 100:150:100 kg NPK/ha (T<sub>5</sub>) applied in different proportions as 33.3:33.3:33.3 per cent during vegetative phase, 33.3:33.3:33.3 per cent during bud phase and 33.3:33.3:33.3 per cent during flowering phase, resulted in maximum weight of flowers per plant (50.01 g). Other treatments T<sub>1</sub> and T<sub>4</sub> (46.72 g and 46.63 g, respectively) found to be at par with this. In contrast, minimum weight of flowers per plant (41.65 g) was noted with T<sub>3</sub> i.e. 33.3:33.3:33.3 per cent NPK (Vegetative phase), 33.3:33.3:33.3 per cent NPK (Bud phase), 33.3:33.3:33.3 per cent NPK (Flowering phase) of 75:112.5:75 kg NPK/ha.

Interaction between cultivars and nutritional treatments revealed maximum weight of flowers per plant with T<sub>5</sub> in the cultivar ‘Pusa Shwet’ (73.78 g). However, minimum weight of flowers per plant was noted with T<sub>2</sub> in cultivar ‘Purnima’ (18.13 g).

**Table 4.8 Effect of phenophase based application of nutritional treatments on weight of flowers per plant (g) of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima      | Pusa Shwet   | Mean  |
|------------------------|--------------|--------------|-------|
| *T <sub>1</sub>        | 21.80        | 71.64        | 46.72 |
| T <sub>2</sub>         | 18.13        | 72.96        | 45.55 |
| T <sub>3</sub>         | 18.67        | 64.63        | 41.65 |
| T <sub>4</sub>         | 22.26        | 71.00        | 46.63 |
| T <sub>5</sub>         | 26.23        | 73.78        | 50.01 |
| <b>Mean</b>            | <b>21.42</b> | <b>70.81</b> | ----- |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

**CD<sub>0.05</sub> for:**

|                                    |        |
|------------------------------------|--------|
| Cultivars                          | : 2.33 |
| Nutritional treatments             | : 3.69 |
| Cultivars X Nutritional treatments | : NS   |

Availability of NPK in the growing medium and their uptake is very important for plant growth. The increase in flower weight due to nitrogen application may be attributed to the abundant supply of nitrogen that helped to increase the assimilations required to increase the weight Sheoran *et al.* (2016). Similar finding was also reported by Kadu *et al.* (2009), Kabir *et al.* (2011). Phosphorus is one of the major elements and being a constituent of nucleoprotein, it is known to play a vital role in photosynthesis, cell division and tissue formation (Arnon, 1959). Potassium helps in water economy, energy metabolism and enzymes activity Mengel and Kirby (1980), which have positive effect on flower weight. The response of NPK in the present case when applied based on phenophases varied with the cultivar for weight of flowers per plant as in case of ‘Purnima’ (26.23), T<sub>5</sub> was found best while ‘Pusa Shwet’ (73.78) showed maximum weight of flowers per plant with the application of T<sub>5</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

#### 4.9 DURATION OF FLOWERING (days)

Data pertaining to duration of flowering of two cultivars of chrysanthemum namely; ‘Purnima’ and ‘Pusa Shwet’ is presented in Table 4.9. Variation in duration of flowering due to cultivars and their interaction were found to be significant. However, nutritional treatments were found to be non-significant.

Perusal of data revealed more duration of flowering in case of cultivar ‘Pusa Shwet’ (27.26 days) as compared to ‘Purnima’ (22.43 days).

**Table 4.9 Effect of phenophase based application of nutritional treatments on duration of flowering (days) of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima      | Pusa Shwet   | Mean         |
|------------------------|--------------|--------------|--------------|
| *T <sub>1</sub>        | 21.37        | 26.19        | <b>23.78</b> |
| T <sub>2</sub>         | 23.96        | 25.19        | <b>24.58</b> |
| T <sub>3</sub>         | 23.08        | 27.69        | <b>25.39</b> |
| T <sub>4</sub>         | 21.78        | 27.63        | <b>24.71</b> |
| T <sub>5</sub>         | 21.96        | 29.58        | <b>25.77</b> |
| <b>Mean</b>            | <b>22.43</b> | <b>27.26</b> | <b>---</b>   |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

#### CD<sub>0.05</sub> for:

|                                    |        |
|------------------------------------|--------|
| Cultivars                          | : 0.98 |
| Nutritional treatments             | : NS   |
| Cultivars X Nutritional treatments | : 1.98 |

Among different nutritional treatments, application 100:150:100 kg NPK/ha (T<sub>5</sub>) applied in different proportions as 33.3:33.3:33.3 per cent during vegetative phase, 33.3:33.3:33.3 per cent during bud phase and 33.3:33.3:33.3 per cent during flowering phase, resulted in maximum duration of flowering (25.77 days). In contrast, minimum duration of flowering (23.78 days) was recorded with T<sub>1</sub> i.e. 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching.

Interaction between cultivars and nutritional treatments, revealed maximum duration of flowering with T<sub>5</sub> in the cultivar ‘Pusa Shwet’ (29.58 days) which was statistically at par with nutritional treatment T<sub>3</sub> and T<sub>4</sub> (27.69 days and 27.63 days, respectively) in the same cultivar. However, minimum duration of flowering was noted with T<sub>1</sub> in cultivar ‘Purnima’ (21.37 days) which was statistically at par with nutritional treatments T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub> (23.08 days, 21.78 days and 21.96 days, respectively).

Availability of NPK in the growing medium and their uptake is very important for plant growth. Increase in duration of flowering due to the application of nitrogen, results in greater assimilation of carbohydrates in plant Saini *et al.* (1978). Duration of flowering was increased with application of phosphorus (Table 4.9). Similar results have been reported by Sehrawat *et al.* (2003) in marigold. The response of NPK in the present case when applied based on phenophases varied with the cultivar for duration of flowering as in case of ‘Purnima’ (23.96 days), T<sub>2</sub> was found best while, ‘Pusa Shwet’ (29.58 days) showed maximum plant height with the application of T<sub>3</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

#### **4.10 VASE LIFE (days)**

Data pertaining to vase life of two cultivars of chrysanthemum namely; ‘Purnima’ and ‘Pusa Shwet’ is presented in Table 4.10. Variation in vase life due to cultivar, nutritional treatments and their interaction were found to be significant.

Perusal of data revealed more vase life in case of cultivar ‘Pusa Shwet’ (21.20 days) as compared to ‘Purnima’ (18.93 days).

Among different nutritional treatments, basal application of 100:150:100 kg NPK/ha (T<sub>2</sub>) applied in different proportions as 40:20:20 per cent during vegetative phase, 30:40:40 per cent during bud stage and 30:40:40 per cent during flowering phase, resulted in maximum vase life (21.06 days). Other treatments, T<sub>1</sub> and T<sub>5</sub> (20.37 and 20.34 days, respectively) were also found to be at par with T<sub>2</sub>. However, minimum vase life (18.87 days) was recorded with T<sub>4</sub> i.e. 40:20:20 per cent NPK (Vegetative phase), 30:40:40 per cent NPK (Bud phase), 30:40:40 per cent NPK (Flowering phase) of 75:112.5:75 kg NPK/ha which was statistically at par with nutritional treatments T<sub>3</sub> (20.37 days).

**Table 4.10 Effect of phenophase based application of nutritional treatments on vase life (days) of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima      | Pusa Shwet   | Mean         |
|------------------------|--------------|--------------|--------------|
| *T <sub>1</sub>        | 20.36        | 20.37        | <b>20.37</b> |
| T <sub>2</sub>         | 19.19        | 22.92        | <b>21.06</b> |
| T <sub>3</sub>         | 19.10        | 20.30        | <b>19.70</b> |
| T <sub>4</sub>         | 17.52        | 20.22        | <b>18.87</b> |
| T <sub>5</sub>         | 18.50        | 22.18        | <b>20.34</b> |
| <b>Mean</b>            | <b>18.93</b> | <b>21.20</b> | <b>-----</b> |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

**CD<sub>0.05</sub> for:**

|                                    |        |
|------------------------------------|--------|
| Cultivars                          | : 0.71 |
| Nutritional treatments             | : 1.12 |
| Cultivars X Nutritional treatments | : 1.58 |

Interaction between cultivars and nutritional treatments, revealed maximum vase life with T<sub>2</sub> in the cultivar ‘Pusa Shwet’ (22.92 days) which was statistically at par with nutritional treatment T<sub>5</sub> (22.18 days) in the same cultivar. However, minimum vase life was noted in T<sub>4</sub> in cultivar ‘Purnima’ (17.52 days) which was statistically at par with nutritional treatments T<sub>5</sub> (18.50 days) in the same cultivar.

Availability of NPK in the growing medium and their uptake is very important for plant growth. Nitrogen enhances the vase life by producing carbohydrates that prolong the vase life but with increase in nitrogen, there is depletion in carbohydrates causing digestion of proteins that could reduce sugar content, an important factor in extending vase life in chrysanthemum. However, increased nitrogen causes a decline in post-harvest life. The higher vase life might be due to optimum availability of nutrients and higher level of potash. While, potash enhances the synthesis, metabolism and translocation of carbohydrates, synthesis of protein with rapid cell division and differentiation, which results in better post-harvest life of flowers Haque and Jakhro (2001). The response of NPK in the present case when applied based on phenophases varied with the cultivar for vase life as in case of ‘Purnima’ (20.36 days), T<sub>1</sub> was found best while, ‘Pusa Shwet’ (22.92 days) showed

maximum plant height with the application of T<sub>3</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

#### 4.11 AVAILABLE SOIL NPK (kg/ha), ORGANIC CARBON (%), pH AND EC (dS/m)

##### 4.11.1 Available nitrogen (kg/ha)

Data pertaining to available nitrogen of two cultivars of chrysanthemum namely; ‘Purnima’ and ‘Pusa Shwet’ is presented in Table 4.11.1. Variation in available nitrogen due to cultivars, nutritional treatments and their interaction were found to be non-significant.

Perusal of data revealed more available nitrogen in case of cultivar ‘Purnima’ (134.71 kg/ha) as compared to Pusa Shwet’ (134.68 kg/ha).

**Table 4.11.1 Effect of phenophase based application of nutritional treatments on available nitrogen (kg/ha) of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima       | Pusa Shwet    | Mean          |
|------------------------|---------------|---------------|---------------|
| *T <sub>1</sub>        | 131.71        | 131.89        | <b>131.80</b> |
| T <sub>2</sub>         | 135.89        | 131.76        | <b>133.83</b> |
| T <sub>3</sub>         | 133.98        | 135.89        | <b>134.93</b> |
| T <sub>4</sub>         | 133.80        | 137.98        | <b>135.89</b> |
| T <sub>5</sub>         | 138.16        | 135.89        | <b>137.03</b> |
| <b>Mean</b>            | <b>134.71</b> | <b>134.68</b> | <b>-----</b>  |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

#### CD<sub>0.05</sub> for:

|                                    |      |
|------------------------------------|------|
| Cultivars                          | : NS |
| Nutritional treatments             | : NS |
| Cultivars X Nutritional treatments | : NS |

Among different nutritional treatments, basal application of 100:150:100kg NPK/ha (T<sub>5</sub>) applied at different proportions as 33.3:33.3:33.3 per cent during vegetative phase, 33.3:33.3:33.3 per cent during bud phase and 33.3:33.3:33.3 per cent during flowering phase, resulted in maximum available nitrogen (137.03 kg/ha). In contrast, minimum available

nitrogen (131.80 kg/ha) was recorded with T<sub>1</sub> i.e. 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching.

Interaction between cultivars and nutritional treatments, revealed maximum available nitrogen with T<sub>5</sub> in the cultivar 'Purnima' (138.16 kg/ha). However, minimum available nitrogen was noted in T<sub>1</sub> in cultivar 'Purnima' (131.71 kg/ha).

Availability of NPK in the growing medium and their uptake is very important for overall plant growth. The response of NPK in the present case when applied based on phenophases varied with the cultivar for available nitrogen as in case of 'Purnima' (138.16 kg/ha), T<sub>5</sub> was found best while 'Pusa Shwet' (137.98) showed maximum plant height with the application of T<sub>4</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

#### **4.11.2 Available phosphorus (kg/ha)**

Data pertaining to available phosphorus of two cultivars of chrysanthemum namely; 'Purnima' and 'Pusa Shwet' is presented in Table 4.11.2. Variation in available phosphorus due to cultivars, nutritional treatments and their interaction were found to be non-significant.

Perusal of data revealed more available phosphorus in case of cultivar 'Purnima' (24.50 kg/ha) as compared to 'Pusa Shwet' (24.14 kg/ha).

Among different nutritional treatments, basal application of 100:150:100kg NPK/ha (T<sub>5</sub>) applied at different proportions as 40:20:20 per cent during vegetative phase, 30:40:40 per cent during bud phase and 30:40:40 per cent during flowering phase resulted in maximum available phosphorus (25.21 kg/ha). In contrast, minimum available phosphorus (23.33 kg/ha) was recorded with T<sub>3</sub> i.e. 33.3:33.3:33.3 per cent NPK (Vegetative phase), 33.3:33.3:33.3 per cent NPK (Bud phase), 33.3:33.3:33.3 per cent NPK (Flowering phase) @ 75:112.5:75 kg NPK/ha.

Interaction between cultivars and nutritional treatments, revealed maximum available phosphorus with T<sub>4</sub> in the cultivar 'Purnima' (25.87 kg/ha). However, minimum available phosphorus was noted in T<sub>1</sub> in cultivar 'Pusa Shwet' (22.84 kg/ha).

Availability of NPK in the growing medium and their uptake is very important for plant growth. The response of NPK in the present case when applied based on phenophases varied with the cultivar for available phosphorus as in case of ‘Purnima’ (25.87 kg/ha), T<sub>4</sub> was found best while ‘Pusa Shwet’ (24.80 kg/ha) showed maximum plant height with the application of T<sub>1</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

**Table 4.11.2 Effect of phenophase based application of nutritional treatments on available phosphorus (kg/ha) of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima      | Pusa Shwet   | Mean         |
|------------------------|--------------|--------------|--------------|
| *T <sub>1</sub>        | 24.51        | 24.80        | <b>24.66</b> |
| T <sub>2</sub>         | 23.82        | 22.84        | <b>23.33</b> |
| T <sub>3</sub>         | 23.48        | 24.47        | <b>23.98</b> |
| T <sub>4</sub>         | 25.87        | 24.55        | <b>25.21</b> |
| T <sub>5</sub>         | 24.80        | 24.05        | <b>24.43</b> |
| <b>Mean</b>            | <b>24.50</b> | <b>24.14</b> | -----        |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizer. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizer. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

**CD<sub>0.05</sub> for:**

|                                    |      |
|------------------------------------|------|
| Cultivars                          | : NS |
| Nutritional treatments             | : NS |
| Cultivars X Nutritional treatments | : NS |

#### **4.11.3 Available potassium (kg/ha)**

Data pertaining to available potassium of two cultivars of chrysanthemum namely; ‘Purnima’ and ‘Pusa Shwet’ is presented in Table 4.11.3. Variation in available potassium due to cultivars, and their interactions were found to be non-significant. However, nutritional treatments were found to be significant.

Perusal of data revealed more available potassium in case of cultivar ‘Purnima’ (106.47 kg/ha) as compared to ‘Pusa Shwet’ (106.02 kg/ha).

Among different nutritional treatments, basal application of 75:112.5:75 kg NPK/ha (T<sub>4</sub>) applied in different proportions as 40:20:20 per cent during vegetative phase, 30:40:40 per cent bud phase and 30:40:40 per cent during flowering phase, resulted in maximum available potassium (107.98 kg/ha). However, minimum available potassium (105.01 kg/ha) was recorded with T<sub>1</sub> i.e. 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching

Interaction between cultivars and nutritional treatments, revealed maximum available potassium with T<sub>4</sub> in the cultivar 'Purnima' (108.11 kg/ha). However, minimum available potassium was noted in T<sub>3</sub> in the cultivar 'Pusa Shwet' (104.81 kg/ha).

Availability of NPK in the growing medium and their uptake is very important for plant growth. The response of NPK in the present case when applied based on phenophases varied with the cultivar for available potassium as in case of 'Purnima' (108.11 kg/ha), T<sub>4</sub> was found best while 'Pusa Shwet' (107.85 kg/ha) showed maximum available potassium with the application of T<sub>4</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars

**Table 4.11.3 Effect of phenophase based application of nutritional treatments on available potassium (kg/ha) of chrysanthemum cultivars 'Purnima' and 'Pusa Shwet'**

| Nutritional treatments | Purnima       | Pusa Shwet    | Mean          |
|------------------------|---------------|---------------|---------------|
| *T <sub>1</sub>        | 105.20        | 104.82        | <b>105.01</b> |
| T <sub>2</sub>         | 107.14        | 106.17        | <b>106.65</b> |
| T <sub>3</sub>         | 105.73        | 104.81        | <b>105.27</b> |
| T <sub>4</sub>         | 108.11        | 107.85        | <b>107.98</b> |
| T <sub>5</sub>         | 106.17        | 106.44        | <b>106.30</b> |
| <b>Mean</b>            | <b>106.47</b> | <b>106.02</b> | -----         |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

**CD<sub>0.05</sub> for:**

|                                    |        |
|------------------------------------|--------|
| Cultivars                          | : NS   |
| Nutritional treatments             | : 1.98 |
| Cultivars X Nutritional treatments | : NS   |

#### 4.11.4 Organic carbon (%)

Data pertaining to available organic carbon of two cultivars of chrysanthemum namely; ‘Purnima’ and ‘Pusa Shwet’ is presented in Table 4.11.4. Variation in available organic carbon due to cultivars, nutritional treatments and their interactions were found to be non-significant.

Perusal of data revealed equal available organic carbon for both the cultivar ‘Purnima’ and ‘Pusa Shwet’ (1.38 %).

Among different nutritional treatments, basal application of 100:150:100 kg NPK/ha (T<sub>5</sub>) applied in different proportions as 33.3:33.3:33.3 % during vegetative phase, 33.3:33.3:33.3 % during bud phase and 33.3:33.3:33.3 % during flowering phase @100:150:100 kg NPK/ha, resulted in maximum available organic carbon (1.39 %). However, minimum available organic carbon (1.35 %) was recorded with T<sub>3</sub> i.e. 33.3:33.3:33.3 per cent NPK (Vegetative phase), 33.3:33.3:33.3 per cent NPK (Bud phase), 33.3:33.3:33.3 per cent NPK (Flowering phase) of 75:112.5:75kg NPK/ha.

**Table 4.11.4 Effect of phenophase based application of nutritional treatments on available organic carbon (%) of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima     | Pusa Shwet  | Mean         |
|------------------------|-------------|-------------|--------------|
| *T <sub>1</sub>        | 1.38        | 1.38        | <b>1.38</b>  |
| T <sub>2</sub>         | 1.36        | 1.37        | <b>1.37</b>  |
| T <sub>3</sub>         | 1.34        | 1.35        | <b>1.35</b>  |
| T <sub>4</sub>         | 1.36        | 1.36        | <b>1.36</b>  |
| T <sub>5</sub>         | 1.38        | 1.39        | <b>1.39</b>  |
| <b>Mean</b>            | <b>1.38</b> | <b>1.38</b> | <b>-----</b> |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

**CD<sub>0.05</sub> for:**

|                                    |      |
|------------------------------------|------|
| Cultivars                          | : NS |
| Nutritional treatments             | : NS |
| Cultivars X Nutritional treatments | : NS |

Interaction between cultivars and nutritional treatments, revealed maximum available organic carbon with T<sub>5</sub> in the cultivar 'Pusa Shwet' (1.39 %). However, minimum available organic carbon was noted in T<sub>3</sub> in the cultivar 'Purnima' (1.34 %).

Availability of NPK in the growing medium and their uptake is very important for plant growth. The response of NPK in the present case when applied based on phenophases varied with the cultivar for organic carbon as in case of 'Purnima' (1.38 %), T<sub>1</sub> and T<sub>4</sub> was found best while 'Pusa Shwet' (1.39 %) showed maximum organic carbon with the application of T<sub>4</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

#### **4.11.5 pH**

Data pertaining to available soil pH of two cultivars of chrysanthemum namely; 'Purnima' and 'Pusa Shwet' is presented in Table 4.11.5. Variation in pH due to cultivars, and their interaction were found to be non-significant while nutritional treatments were recorded significant.

Perusal of data revealed more pH in case of cultivar 'Pusa Shwet' (6.91) as compared to 'Purnima' (6.89).

Among different nutritional treatments, basal application of @ 100:150:100 kg NPK/ha T<sub>2</sub> at different proportions 40:20:20 per cent during vegetative phase, 30:40:40 per cent during bud phase and 30:40:40 per cent at flowering phase, resulted in maximum pH (6.96). However, minimum pH (6.88) was recorded with T<sub>3</sub> and T<sub>5</sub>.

Interaction between cultivars and nutritional treatments, revealed maximum pH with T<sub>2</sub> in the cultivar 'Pusa Shwet' (6.99). However, minimum pH was noted with T<sub>1</sub> and T<sub>3</sub> in the cultivar 'Purnima' (6.87) and T<sub>5</sub> in the cultivar 'Pusa Shwet' (6.87).

Availability of NPK in the growing medium and their uptake is very important for plant growth. The response of NPK in the present case when applied based on phenophases varied with the cultivar for pH in case of 'Purnima' (6.93), T<sub>2</sub> was found best while 'Pusa Shwet' (6.99) showed maximum pH with the application of T<sub>2</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

**Table 4.11.5 Effect of phenophase based application of nutritional treatments on pH of chrysanthemum cultivar ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima     | Pusa Shwet  | Mean         |
|------------------------|-------------|-------------|--------------|
| *T <sub>1</sub>        | 6.87        | 6.91        | <b>6.89</b>  |
| T <sub>2</sub>         | 6.93        | 6.99        | <b>6.96</b>  |
| T <sub>3</sub>         | 6.87        | 6.89        | <b>6.88</b>  |
| T <sub>4</sub>         | 6.89        | 6.88        | <b>6.89</b>  |
| T <sub>5</sub>         | 6.88        | 6.87        | <b>6.88</b>  |
| <b>Mean</b>            | <b>6.89</b> | <b>6.91</b> | <b>-----</b> |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

**CD<sub>0.05</sub> for:**

|                                    |        |
|------------------------------------|--------|
| Cultivars                          | : NS   |
| Nutritional treatments             | : 0.04 |
| Cultivars X Nutritional treatments | : NS   |

**4.11.6 EC (dS/m)**

Data pertaining to soil EC of two cultivars of chrysanthemum namely; ‘Purnima’ and ‘Pusa Shwet’ is presented in Table 4.11.6. Variation in EC due to cultivars, nutritional treatments and their interaction were found to be non-significant.

Perusal of data revealed significantly more EC in case of cultivar ‘Pusa Shwet’ (0.36 dS/m) as compared to ‘Purnima’ (0.35 dS/m).

Among different nutritional treatments, T<sub>1</sub> basal application of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching and basal application of 100:150:100 kg NPK/ha (T<sub>2</sub>) applied in different proportions as 40:20:20 % during vegetative phase, 30:40:40 % during bud phase and 30:40:40 % during flowering phase, resulted in maximum EC (0.37 dS/m). However, minimum EC (0.34 dS/m) was recorded with T<sub>4</sub> i.e. 40:20:20 per cent NPK (Vegetative phase), 30:40:40 per cent NPK (Bud phase), 30:40:40 per cent (Flowering phase) @75:112.5:75 kg NPK/ha. .

**Table 4.11.6 Effect of phenophase based application of nutritional treatments on EC (dS/m) of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima     | Pusa Shwet  | Mean        |
|------------------------|-------------|-------------|-------------|
| *T <sub>1</sub>        | 0.36        | 0.37        | <b>0.37</b> |
| T <sub>2</sub>         | 0.38        | 0.35        | <b>0.37</b> |
| T <sub>3</sub>         | 0.34        | 0.38        | <b>0.36</b> |
| T <sub>4</sub>         | 0.32        | 0.36        | <b>0.34</b> |
| T <sub>5</sub>         | 0.35        | 0.34        | <b>0.35</b> |
| <b>Mean</b>            | <b>0.35</b> | <b>0.36</b> |             |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizers. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizers. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

**CD<sub>0.05</sub> for:**

|                                    |      |
|------------------------------------|------|
| Cultivars                          | : NS |
| Nutritional treatments             | : NS |
| Cultivars X Nutritional treatments | : NS |

Interaction between cultivars and nutritional treatments, revealed maximum EC with T<sub>2</sub> in the cultivar ‘Purnima’ (0.32 dS/m) and T<sub>3</sub> in the cultivar ‘Pusa Shwet’ (0.38 dS/m). However, minimum available EC was noted in T<sub>4</sub> in the cultivar ‘Purnima’ (0.32 dS/m).

Availability of NPK in the growing medium and their uptake is very important for plant growth. The response of NPK in the present case when applied based on phenophases varied with the cultivar for EC as in case of ‘Purnima’ (0.38 dS/m ), T<sub>2</sub> was found best while ‘Pusa Shwet’ (0.38 dS/m )showed maximum plant height with the application of T<sub>3</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

#### **4. 12. COST OF CULTIVATION (B:C ratio)**

The analysis of cost of production of chrysanthemum on an area of one bigha (800 m<sup>2</sup>) was done to calculate the cost benefit ratio Table 4.12. It was calculated by taking into account the cost of land preparation, planting, intercultural operations, material inputs and intercultural operation expenses with the labour charges as Rs 300.0 per man day were considered. The average yield data was considered to work out the total results and calculation of net profit and cost benefit ratio.

**Table 4.12 Cost of cultivation of chrysanthemum on an area of one bigha (800m<sup>2</sup>)**

| Sr. No. | Particulars/Items                            | Quantity required              | Cost/unit (Rs)                              | Total cost (Rs)          |                          |
|---------|----------------------------------------------|--------------------------------|---------------------------------------------|--------------------------|--------------------------|
| A1.     | Fixed cost                                   |                                |                                             |                          |                          |
| 1.      | Polyhouse                                    | 800m <sup>2</sup> for 250 days | 5% of Rs. 1040/m <sup>2</sup> for 365 days* | 28493.15                 |                          |
| 2.      | Rooted cuttings                              | 5400                           | 4.00                                        | 21600.00                 |                          |
| 3.      | FYM                                          | 1200kg                         | 185/100kg                                   | 2220.00                  |                          |
| 4.      | Neem                                         | 12kg                           | 97/kg                                       | 1164.00                  |                          |
| 5.      | Trichoderma harzianum                        | 0.06kg                         | 200/kg                                      | 12.00                    |                          |
| 6.      | Cannon (Chlorpyriphos 50 %+ Cypermethrin EC) | 135ml                          | 850/l                                       | 115.00                   |                          |
| 7.      | Decis (Deltamethrin 2.8 EC )                 | 180ml                          | 1500/l                                      | 180.00                   |                          |
| 8.      | Coragen (Chlorantranilliprol E 18.5% SC)     | 72ml                           | 530/30ml                                    | 1272.24                  |                          |
| 9.      | Dithane M-45                                 | 840g                           | 180/500gm                                   | 302.40                   |                          |
| 10.     | Bavistin                                     | 420g                           | 80/100gm                                    | 336.00                   |                          |
| 11.     | Sticky traps                                 | 5.00                           | 50.00                                       | 250.00                   |                          |
|         | Total                                        |                                |                                             | 55944.79                 |                          |
| B1.     | Variable cost                                |                                |                                             |                          |                          |
| Sr.No.  | Particulars                                  | Quantity required (man days)   |                                             | Total cost (mandays×300) |                          |
| 1.      | Labour @ Rs 300 per Man day                  | Purnima                        | Pusa Shwet                                  | Purnima                  | Pusa Shwet               |
|         |                                              | T <sub>1</sub> =87.04          | T <sub>1</sub> =98.49                       | T <sub>1</sub> =26112.00 | T <sub>1</sub> =29547.00 |
|         |                                              | T <sub>2</sub> =85.12          | T <sub>2</sub> =98.49                       | T <sub>2</sub> =25536.00 | T <sub>2</sub> =29547.00 |
|         |                                              | T <sub>3</sub> =87.04          | T <sub>3</sub> =97.28                       | T <sub>3</sub> =26112.00 | T <sub>3</sub> =29184.00 |
|         |                                              | T <sub>4</sub> =84.48          | T <sub>4</sub> =97.92                       | T <sub>4</sub> =25344.00 | T <sub>4</sub> =29376.00 |
|         |                                              | T <sub>5</sub> =85.12          | T <sub>5</sub> =97.92                       | T <sub>5</sub> =25536.00 | T <sub>5</sub> =27376.00 |
| 2.      | NPK                                          |                                |                                             |                          |                          |
|         | Urea @ Rs 254 per 50 kg                      | Purnima                        | Pusa Shwet                                  | Purnima                  | Pusa Shwet               |
|         |                                              | T <sub>1</sub> =13044.00       | T <sub>1</sub> =13044.00                    | T <sub>1</sub> =66.26    | T <sub>1</sub> =66.26    |
|         |                                              | T <sub>2</sub> =13044.00       | T <sub>2</sub> =13044.00                    | T <sub>2</sub> =66.26    | T <sub>2</sub> =66.26    |
|         |                                              | T <sub>3</sub> =9780.00        | T <sub>3</sub> =9780.00                     | T <sub>3</sub> =49.68    | T <sub>3</sub> =49.68    |
|         |                                              | T <sub>4</sub> =9780.00        | T <sub>4</sub> =9780.00                     | T <sub>4</sub> =49.68    | T <sub>4</sub> =49.68    |
|         |                                              | T <sub>5</sub> =13044.00       | T <sub>5</sub> =13044.00                    | T <sub>5</sub> =66.26    | T <sub>5</sub> =66.26    |

|    |                                            |                          |                        |                           |                          |
|----|--------------------------------------------|--------------------------|------------------------|---------------------------|--------------------------|
|    | SSP @ Rs 495 per 50kg                      | <b>Purnima</b>           | <b>Pusa Shwet</b>      | <b>Purnima</b>            | <b>Pusa Shwet</b>        |
|    |                                            | T <sub>1</sub> =56250.00 | T <sub>1</sub> =556.88 | T <sub>1</sub> =56250.00  | T <sub>1</sub> =13044.00 |
|    |                                            | T <sub>2</sub> =56250.00 | T <sub>2</sub> =556.88 | T <sub>2</sub> =56250.00  | T <sub>2</sub> =13044.00 |
|    |                                            | T <sub>3</sub> =6750.00  | T <sub>3</sub> =49.68  | T <sub>3</sub> =6750.00   | T <sub>3</sub> =9780.00  |
|    |                                            | T <sub>4</sub> =9780.00  | T <sub>4</sub> =49.68  | T <sub>4</sub> =9780.00   | T <sub>4</sub> =9780.00  |
|    |                                            | T <sub>5</sub> =56250.00 | T <sub>5</sub> =66.26  | T <sub>5</sub> =56250.00  | T <sub>5</sub> =13044.00 |
|    | MOP@ Rs 840 per 50kg                       | <b>Purnima</b>           | <b>Pusa Shwet</b>      | <b>Purnima</b>            | <b>Pusa Shwet</b>        |
|    |                                            | T <sub>1</sub> =9960.00  | T <sub>1</sub> =167.33 | T <sub>1</sub> =9960.00   | T <sub>1</sub> =167.33   |
|    |                                            | T <sub>2</sub> =10020.00 | T <sub>2</sub> =168.34 | T <sub>2</sub> =10020.00  | T <sub>2</sub> =168.34   |
|    |                                            | T <sub>3</sub> =7500.00  | T <sub>3</sub> =126.00 | T <sub>3</sub> =7500.00   | T <sub>3</sub> =126.00   |
|    |                                            | T <sub>4</sub> =7500.00  | T <sub>4</sub> =126.00 | T <sub>4</sub> =7500.00   | T <sub>4</sub> =126.00   |
|    |                                            | T <sub>5</sub> =10002.00 | T <sub>5</sub> =168.00 | T <sub>5</sub> =168.03    | T <sub>5</sub> =168.03   |
| 3. | <b>Transport</b>                           |                          |                        |                           |                          |
|    | Flower (Rs 200/box)<br>(400 cut stems/box) | <b>Purnima</b>           | <b>Pusa Shwet</b>      | <b>Purnima</b>            | <b>Pusa Shwet</b>        |
|    |                                            | T <sub>1</sub> =32.81    | T <sub>1</sub> =48.19  | T <sub>1</sub> =6561.00   | T <sub>1</sub> =9639.00  |
|    |                                            | T <sub>2</sub> =32.40    | T <sub>2</sub> =50.89  | T <sub>2</sub> =6480.00   | T <sub>2</sub> =10179.00 |
|    |                                            | T <sub>3</sub> =28.76    | T <sub>3</sub> =54.00  | T <sub>3</sub> =5751.00   | T <sub>3</sub> =10800.00 |
|    |                                            | T <sub>4</sub> =31.05    | T <sub>4</sub> =103.95 | T <sub>4</sub> =6210.00   | T <sub>4</sub> =20790.00 |
|    |                                            | T <sub>5</sub> =39.56    | T <sub>5</sub> =223.69 | T <sub>5</sub> =7911.00   | T <sub>5</sub> =44739.00 |
| 4. | <b>Cost of box</b>                         |                          |                        |                           |                          |
|    | Box cost-Rs 70/box                         | <b>Purnima</b>           | <b>Pusa Shwet</b>      | <b>Purnima</b>            | <b>Pusa Shwet</b>        |
|    |                                            | T <sub>1</sub> =32.81    | T <sub>1</sub> =48.19  | T <sub>1</sub> =2296.35   | T <sub>1</sub> =3373.65  |
|    |                                            | T <sub>2</sub> =32.40    | T <sub>2</sub> =50.89  | T <sub>2</sub> =2268.00   | T <sub>2</sub> =3562.65  |
|    |                                            | T <sub>3</sub> =28.76    | T <sub>3</sub> =54.00  | T <sub>3</sub> =2012.85   | T <sub>3</sub> =3780.00  |
|    |                                            | T <sub>4</sub> =31.05    | T <sub>4</sub> =103.95 | T <sub>4</sub> =2173.50   | T <sub>4</sub> =7276.50  |
|    |                                            | T <sub>5</sub> =39.56    | T <sub>5</sub> =223.69 | T <sub>5</sub> =2768.85   | T <sub>5</sub> =15658.65 |
| 5. | <b>Total cost of expenditure (A1+ B1)</b>  |                          |                        |                           |                          |
|    |                                            | <b>Purnima</b>           |                        | <b>Pusa Shwet</b>         |                          |
|    |                                            | T <sub>1</sub> =9196.61  |                        | T <sub>1</sub> =98944.91  |                          |
|    |                                            | T <sub>2</sub> =91389.26 |                        | T <sub>2</sub> =99724.92  |                          |
|    |                                            | T <sub>3</sub> =90749.96 |                        | T <sub>3</sub> =100047.11 |                          |
|    |                                            | T <sub>4</sub> =90514.61 |                        | T <sub>4</sub> =113924.34 |                          |
|    |                                            | T <sub>5</sub> =93281.81 |                        | T <sub>5</sub> =146254.61 |                          |

|     |                                                |                           |                          |                           |                           |
|-----|------------------------------------------------|---------------------------|--------------------------|---------------------------|---------------------------|
| C1. | Returns                                        |                           |                          |                           |                           |
|     | Cut flowers (@ Rs 5/cut stems                  | Purnima                   | Pusa Shwet               | Purnima                   | Pusa Shwet                |
|     |                                                | T <sub>1</sub> =13122.00  | T <sub>1</sub> =19278.00 | T <sub>1</sub> =65610.00  | T <sub>1</sub> =96390.00  |
|     |                                                | T <sub>2</sub> =12960.00  | T <sub>2</sub> =20358.00 | T <sub>2</sub> =64800.00  | T <sub>2</sub> =101790.00 |
|     |                                                | T <sub>3</sub> =57510.00  | T <sub>3</sub> =21600.00 | T <sub>3</sub> =57510.00  | T <sub>3</sub> =108000.00 |
|     |                                                | T <sub>4</sub> =62100.00  | T <sub>4</sub> =25002.00 | T <sub>4</sub> =62100.00  | T <sub>4</sub> =125010.00 |
|     |                                                | T <sub>5</sub> =79110.00  | T <sub>5</sub> =24300.00 | T <sub>5</sub> =79110.00  | T <sub>5</sub> =121500.00 |
|     | Suckers (@ Rs 4/suckers                        | Purnima                   | Pusa Shwet               | Purnima                   | Pusa Shwet                |
|     |                                                | T <sub>1</sub> =41418.00  | T <sub>1</sub> =39582.00 | T <sub>1</sub> =165672.00 | T <sub>1</sub> =158328.00 |
|     |                                                | T <sub>2</sub> =66582.00  | T <sub>2</sub> =63018.00 | T <sub>2</sub> =266328.00 | T <sub>2</sub> =252072.00 |
|     |                                                | T <sub>3</sub> =77382.00  | T <sub>3</sub> =23994.00 | T <sub>3</sub> =309528.00 | T <sub>3</sub> =95976.00  |
|     |                                                | T <sub>4</sub> =21600.00  | T <sub>4</sub> =44982.00 | T <sub>4</sub> =86400.00  | T <sub>4</sub> =179928.00 |
|     |                                                | T <sub>5</sub> =68418.00  | T <sub>5</sub> =97200.00 | T <sub>5</sub> =273672.00 | T <sub>5</sub> =388800.00 |
|     | Total returns                                  |                           |                          |                           |                           |
|     |                                                | Purnima                   |                          | Pusa Shwet                |                           |
|     |                                                | T <sub>1</sub> =357858.00 |                          | T <sub>1</sub> =281502.00 |                           |
|     |                                                | T <sub>2</sub> =358560.00 |                          | T <sub>2</sub> =428598.00 |                           |
|     |                                                | T <sub>3</sub> =427518.00 |                          | T <sub>3</sub> =345600.00 |                           |
|     |                                                | T <sub>4</sub> =316980.00 |                          | T <sub>4</sub> =291330.00 |                           |
|     |                                                | T <sub>5</sub> =392310.00 |                          | T <sub>5</sub> =479412.00 |                           |
|     | Net return ( Gross returns-Total cost)         |                           |                          |                           |                           |
|     |                                                | Purnima                   |                          | Pusa Shwet                |                           |
|     |                                                | T <sub>1</sub> =265892.39 |                          | T <sub>1</sub> =182507.09 |                           |
|     |                                                | T <sub>2</sub> =267170.74 |                          | T <sub>2</sub> =328873.08 |                           |
|     |                                                | T <sub>3</sub> =336768.04 |                          | T <sub>3</sub> =245552.89 |                           |
|     |                                                | T <sub>4</sub> =226465.39 |                          | T <sub>4</sub> =177405.66 |                           |
|     |                                                | T <sub>5</sub> =18228.19  |                          | T <sub>5</sub> =333157.39 |                           |
| D.  | Cost benefits ratio (Gross returns÷Total Cost) |                           |                          |                           |                           |
|     | B:C ratio                                      | Treatments                | Purnima                  | Pusa Shwet                |                           |
|     |                                                | T <sub>1</sub>            | 2.52                     | 2.57                      |                           |
|     |                                                | T <sub>2</sub>            | 3.64                     | 3.54                      |                           |
|     |                                                | T <sub>3</sub>            | 4.06                     | 2.03                      |                           |
|     |                                                | T <sub>4</sub>            | 1.65                     | 2.67                      |                           |
|     |                                                | T <sub>5</sub>            | 3.80                     | 3.48                      |                           |

\*Calculated for 250 days only i.e. the period up to which the crop yield was harvested.

The data presented in the Table 4.12 revealed that more B:C ratio in case of cultivar ‘Purnima’ (4.06) as compared to ‘Pusa Shwet’ (3.54).

The data revealed that in cultivar ‘Purnima’ the treatment T<sub>3</sub> recorded maximum cost benefits ratio of (4.06) which was followed by T<sub>5</sub>, T<sub>2</sub>, T<sub>1</sub> and T<sub>4</sub> (3.80, 3.64, 2.52 and 1.65, respectively). While in cultivars ‘Pusa Shwet’ the treatment T<sub>2</sub> recorded maximum benefits cost ratio of (3.54) which was followed by T<sub>5</sub>, T<sub>4</sub>, T<sub>1</sub> and T<sub>4</sub> (3.48, 3.28, 2.84 and 2.56, respectively).

Availability of NPK in the growing medium and their uptake is very important for plant growth. The response of NPK in the present case when applied based on phenophases varied with the cultivar for B:C ratio as in case of ‘Purnima’ (4.06), T<sub>3</sub> was found best while ‘Pusa Shwet’ (3.54) showed maximum B:C ratio with the application of T<sub>2</sub>. The findings clearly indicated that the response of NPK needs to be standardized for different cultivars.

#### **4.13 Number of suckers produced per plant**

Data pertaining to number of suckers produced per plant of two cultivars of chrysanthemum namely; ‘Purnima’ and ‘Pusa Shwet’ is presented in Table 4.13. Variation in number of suckers produced per plant due to cultivars and their interaction were found to be non-significant. However, nutritional treatments were found to be significant.

Perusal of data revealed more number of suckers produced per plant in case of cultivar ‘Pusa Shwet’ (11.73) as compared to ‘Purnima’ (11.20).

Among different nutritional treatments, basal application of @ 100:150:100kg NPK/ha (T<sub>5</sub>) applied in different proportions as 33.3:33.3:33.3 per cent during vegetative phase, 33.3:33.3:33.3 per cent during bud phase and 33.3:33.3:33.3 per cent during flowering phase, resulted in maximum number of suckers produced per plant (15.33) which was statistically at par with nutritional treatments T<sub>3</sub> (12.48). In contrast, minimum number of suckers produced per plants (7.50) was recorded with T<sub>1</sub> i.e. 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits- first as basal, second dose at pinching and third dose one month after pinching which was statistically at par with nutritional treatments T<sub>4</sub> (8.67).

Interaction between cultivars and nutritional treatments, revealed maximum number of suckers produced per plant with T<sub>3</sub> in the cultivar ‘Purnima’ (17.13). However, minimum number of suckers produced per plant was noted with T<sub>4</sub> in cultivar ‘Pusa Shwet’ (7.70).

**Table 4.12 Effect of phenophase based application of nutritional treatments on number of suckers produced per plant of chrysanthemum cultivars ‘Purnima’ and ‘Pusa Shwet’**

| Nutritional treatments | Purnima      | Pusa Shwet   | Mean         |
|------------------------|--------------|--------------|--------------|
| *T <sub>1</sub>        | 7.67         | 7.33         | <b>7.50</b>  |
| T <sub>2</sub>         | 12.33        | 11.67        | <b>12.00</b> |
| T <sub>3</sub>         | 14.33        | 13.33        | <b>13.83</b> |
| T <sub>4</sub>         | 9.00         | 8.33         | <b>8.67</b>  |
| T <sub>5</sub>         | 12.67        | 18.00        | <b>15.33</b> |
| <b>Mean</b>            | <b>11.20</b> | <b>11.73</b> | <b>----</b>  |

\*T<sub>1</sub>: Recommended dose of fertilizers of 100:150:100 kg NPK/ha as soil application (control). Full dose of P and K as basal, N three equal splits -first as basal, second dose at pinching and third dose one month after pinching. T<sub>2</sub>: 40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % NPK (Flowering phase), @ 100:150:100 kg NPK/ha. T<sub>3</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 75:112.5:75kg NPK/ha. T<sub>4</sub>: 40:20:20 % NPK (Vegetative phase) 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering) @75:112.5:75 kg NPK/ha. T<sub>5</sub>: 33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @100:150:100kg NPK/ha. In treatment T<sub>2</sub> to T<sub>5</sub>, 25 % of fertilizer dose was applied as basal dose using straight fertilizer. Remaining 75% was applied as per the treatment details (as given below) using water soluble fertilizer. In addition to this, well decomposed farm yard manure at the rate of 20 t/ha was applied along with 200 kg of neem cake enriched with 1 kg of *Trichoderma harzianum* as a basal dose.

**CD<sub>0.05</sub> for:**

|                                    |        |
|------------------------------------|--------|
| Cultivars                          | : NS   |
| Nutritional treatments             | : 2.85 |
| Cultivars X Nutritional treatments | : NS   |

Availability of NPK in the growing medium and their uptake is very important for plant growth. Nitrogen is a component of chlorophyll and is required for several enzyme reactions resulting in more number of suckers. Similar finding was reported by Patil (1998). Potassium in soil available to plant is dissolved in the soil water. This is taken up by the plant roots and result in development of maximum suckers reported by Ayemi *et al.* (2017) in gerbera. The response of NPK in the present case when applied based on phenophases varied with the cultivar for number of suckers produced per plant as in case of ‘Purnima’ (17.13), T<sub>4</sub> was found best while ‘Pusa Shwet’ (16.57) showed maximum number of suckers produced per plant with the application of T<sub>5</sub>. The findings clearly indicate that the response of NPK needs to be standardized for different cultivars.

## Chapter-5

### SUMMARY AND CONCLUSION

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The present investigation entitled, “**Studies on the effect of N, P and K application at different stages in chrysanthemum (*Chrysanthemum morifolium* Ramat)**” was carried out under a naturally ventilated polyhouse at the Experimental Farm of Department of Floriculture and Landscape Architecture, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during 2019-20. The experiment was laid out in a Randomized Block Design (RBD Factorial) using two cultivars and five treatments with three replications.

The observations recorded were plant height (cm), plant spread (cm), number of days taken for flower bud appearance (days), number of days taken for flower bud opening (days), number of days taken to flowering (days), flower diameter (cm), number of shoots per plant, weight of flowers per plant (g), duration of flowering (days), vase life (days), available NPK (kg/ha), organic carbon (%), pH, EC (dS/m), cost of cultivation (B:C ratio) and number of suckers produced per plant.

#### **The salient results obtained from the present studies are given below:**

- More plant height was recorded in cultivar ‘Pusa Shwet’ (69.76 cm) as compared to ‘Purnima’ (42.49 cm). Among nutritional treatments, maximum and minimum plant height was recorded with T<sub>4</sub> and T<sub>2</sub> (57.87 cm and 52.52 cm), respectively. Interaction effect between cultivars and nutritional treatments revealed that maximum plant height was recorded with T<sub>3</sub> in cultivar ‘Pusa Shwet’ (73.35 cm) while minimum was noted with T<sub>2</sub> in cultivar ‘Purnima’ (38.07 cm).
- More plant spread was recorded in cultivar ‘Pusa Shwet’ (27.97 cm) as compared to ‘Purnima’ (24.06 cm). Among nutritional treatments, maximum and minimum plant spread was recorded with T<sub>4</sub> and T<sub>2</sub> (27.55 cm and 24.53 cm), respectively. Interaction effect between cultivars and nutritional treatments revealed that maximum plant spread was recorded with T<sub>5</sub> in cultivar ‘Pusa Shwet’ (29.83 cm). However, minimum was noted with T<sub>1</sub> in cultivar ‘Purnima’ (22.10 cm).

- Earlier flower bud appearance was noted in 'Purnima' (92.49 days) in comparison to 'Pusa Shwet' (105.80 days). Among nutritional treatments, earliest flower bud appearance was noted with T<sub>4</sub> (97.92 days) while maximum days for flower bud appearance were recorded with T<sub>1</sub> (100.28 days). Interaction effect between cultivars and nutritional treatments revealed that earliest flower bud appearance was noted in T<sub>4</sub> in 'Purnima' (90.17 days). Likewise, T<sub>1</sub> and T<sub>2</sub> in cultivar 'Pusa Shwet' (106.33 days) took maximum days for flower bud appearance.
- Earlier flower bud opening was noted in 'Pusa Shwet' (136.33 days) in comparison to 'Purnima' (127.61 days). Among nutritional treatments, earliest flower bud appearance was noted with T<sub>1</sub> (129.83 days) while maximum days for flower bud appearance were recorded with T<sub>4</sub> (133.37 days). Interaction effect between cultivars and nutritional treatments revealed that earliest flower bud appearance was noted in T<sub>1</sub> 'Purnima' (125.67 days) whereas, T<sub>4</sub> in cultivar 'Pusa Shwet' (140.00 days) took maximum days for flower bud opening.
- Earlier flowering was noted in 'Purnima' (132.49 days) in comparison to 'Pusa Shwet' (151.73 days). Among nutritional treatments, earliest flowering was noted with T<sub>4</sub> (140.91 days) while maximum days for flowering were recorded with T<sub>1</sub> (143.28 days). Interaction effect between cultivars and nutritional treatments revealed that earliest flowering was noted in T<sub>4</sub> in cultivar 'Purnima' (130.17 days) while T<sub>1</sub> and T<sub>2</sub> in cultivar 'Pusa Shwet' (152.33 days) took maximum days to flowering.
- More flower diameter was recorded in cultivar 'Purnima' (10.12 cm) as compared to 'Pusa Shwet' (6.90 cm). Among nutritional treatments, maximum and minimum flower diameter was recorded with T<sub>2</sub> and T<sub>4</sub> (8.87 cm and 8.19 cm, respectively). Interaction effect between cultivars and nutritional treatments revealed that maximum flower diameter was recorded with T<sub>5</sub> in cultivar 'Purnima' (10.57 cm) whereas, minimum was noted with T<sub>4</sub> in cultivar 'Pusa Shwet' (6.43 cm).
- More number of shoots per plant was recorded in cultivar 'Pusa Shwet' (4.09) as compared to 'Purnima' (2.44). Among nutritional treatments, maximum number of shoots per plant was recorded with T<sub>5</sub> (3.72) while minimum in T<sub>1</sub> (3.00). Interaction effect between cultivars and nutritional treatments revealed that maximum number of shoots per plant was recorded with T<sub>4</sub> in cultivar 'Pusa Shwet' (4.63) while minimum was noted with T<sub>3</sub> in cultivar 'Purnima' (2.13).

- More weight of flowers per plant was recorded in cultivar 'Pusa Shwet' (70.81 g) as compared to 'Purnima' (21.42 g). Among nutritional treatments, maximum weight of flowers per plant was recorded in T<sub>5</sub> (50.01 g) while minimum was recorded with T<sub>3</sub> (41.65 g). Interaction effect between cultivars and nutritional treatments revealed that more weight of flowers per plant was observed with T<sub>5</sub> in cultivar 'Pusa Shwet' (73.78 g) while minimum was noted with T<sub>2</sub> in cultivar 'Purnima' (18.13 g).
- More duration of flowering was recorded in cultivar 'Pusa Shwet' (27.26 days) as compared to 'Purnima' (22.43 days). Among nutritional treatments, maximum duration of flowering was noted with T<sub>5</sub> (25.77 days) and minimum was recorded with T<sub>1</sub> (23.78 days). Interaction effect between cultivars and nutritional treatments revealed that maximum duration of flowering was recorded with T<sub>5</sub> in cultivar 'Pusa Shwet' (29.58 days). However, minimum was noted with T<sub>1</sub> in cultivar 'Purnima' (21.37 days).
- More vase life was recorded in cultivar 'Pusa Shwet' (21.20 days) as compared to 'Purnima' (18.93 days). Among nutritional treatments, maximum and minimum vase life was recorded with T<sub>2</sub> and T<sub>4</sub> (21.06 days and 18.87 days), respectively. Interaction effect between cultivars and nutritional treatments revealed that maximum vase life was recorded with T<sub>2</sub> in cultivar 'Pusa Shwet' (22.92 days) while minimum was noted with T<sub>4</sub> in cultivar 'Purnima' (17.52 days).
- More available soil nitrogen was recorded in cultivar 'Purnima' (134.71 kg/ha) as compared to 'Pusa Shwet' (134.68 kg/ha). Among nutritional treatments, maximum and minimum available nitrogen was recorded with T<sub>5</sub> and T<sub>1</sub> (137.03 kg/ha and 131.80 kg/ha, respectively). Interaction effect between cultivars and nutritional treatments revealed that maximum available nitrogen was recorded with T<sub>5</sub> in cultivar 'Purnima' (138.16 kg/ha) whereas, minimum was noted with T<sub>1</sub> in cultivar 'Pusa Shwet' (131.71 kg/ha).
- More available soil phosphorus was recorded in cultivar 'Purnima' (24.50 kg/ha) as compared to 'Pusa Shwet' (24.14 kg/ha). Among nutritional treatments maximum and minimum nitrogen was recorded with T<sub>5</sub> and T<sub>1</sub> (25.21 kg/ha and 23.33 kg/ha, respectively). Interaction effect between cultivars and nutritional treatments revealed that maximum phosphorus was recorded with T<sub>4</sub> in cultivar 'Purnima' (25.87 kg/ha) while minimum was noted with T<sub>2</sub> in cultivar 'Pusa Shwet' (22.84 kg/ha).
- More available potassium was recorded in cultivar 'Purnima' (106.47 kg/ha) as compared to 'Pusa Shwet' (106.02 kg/ha). Among nutritional treatments, maximum

and minimum available potassium was recorded with T<sub>4</sub> and T<sub>1</sub>, (107.98 kg/ha and 105.01 kg/ha), respectively. Interaction effect between cultivars and nutritional treatments revealed that maximum potassium was recorded with T<sub>4</sub> in cultivar ‘Purnima’ (108.11 kg/ha). However minimum was noted with T<sub>3</sub> in cultivar ‘Pusa Shwet’ (104.81 kg/ha).

- Same per cent of organic carbon was recorded in both cultivars ‘Purnima’ and ‘Pusa Shwet’ (1.38 %). Among nutritional treatments, maximum and minimum soil organic carbon was recorded with T<sub>5</sub> and T<sub>3</sub> (1.39 % and 1.35 %, respectively). Interaction effect between cultivars and nutritional treatments revealed that maximum organic carbon was recorded with T<sub>5</sub> in cultivar ‘Pusa Shwet’ (1.39 %) while minimum was noted with T<sub>3</sub> in cultivar ‘Purnima’ (1.34 %).
- High soil pH was recorded in cultivar Pusa Shwet’ (6.91) as compared to ‘Purnima’ (6.89). Among nutritional treatments, maximum soil pH was recorded with T<sub>2</sub> (6.96) whereas, minimum was recorded with T<sub>3</sub> and T<sub>5</sub> (6.88). Interaction effect between cultivars and nutritional treatments revealed that maximum soil pH was recorded with T<sub>2</sub> in cultivar ‘Pusa Shwet’ (6.99) while minimum was noted with T<sub>1</sub> and T<sub>3</sub> in the cultivar ‘Purnima’ and T<sub>5</sub> in cultivar ‘Pusa Shwet’ (6.87).
- High soil EC was recorded in cultivar Pusa Shwet’ (0.36) as compared to ‘Purnima’ (0.35). Among nutritional treatments, maximum EC was recorded with T<sub>1</sub> and T<sub>2</sub> (0.37) whereas, minimum was recorded with T<sub>4</sub> (0.34). Interaction effect between cultivars and nutritional treatments revealed that maximum EC was recorded with T<sub>2</sub> in cultivar ‘Purnima’ and T<sub>3</sub> in the cultivar ‘Pusa Shwet’ (0.38). Likewise, minimum EC was noted with T<sub>4</sub> in the cultivar ‘Purnima’ (0.32).
- In cultivar ‘Pusa Shwet’ maximum B:C ratio was noted in T<sub>3</sub> (4.06) as compared to . ‘Purnima’ (3.54).
- More number of suckers per plant was recorded in cultivar ‘Pusa Shwet’ (11.73 g) as compared to ‘Purnima’ (11.20). Among nutritional treatments, maximum number of suckers per plant was recorded in T<sub>5</sub> (15.33) and minimum was recorded with T<sub>1</sub> (7.50). Interaction effect between cultivars and nutritional treatments revealed that more number of suckers produced per plant was observed with T<sub>5</sub> in cultivar ‘Pusa Shwet’ (18.00). Nevertheless minimum was noted with T<sub>1</sub> in cultivar ‘Purnima’ (7.33).

## **CONCLUSION:**

Application of NPK at different phenophases of chrysanthemum resulted in variable responses due to cultivars. Based upon the studies conducted, application of N, P and K @ 75:112.5:75 kg/ha equally in three doses during vegetative phase, bud phase and flowering phase, resulted in maximum B:C ratio (4.06) in case of 'Purnima'. In cultivar 'Pusa Shwet' NPK application @ of 100:150:100 kg/ha in three splits as 40:20:20 per cent at vegetative phase, 30:40:40 per cent at bud phase and 30:40:40 per cent at flowering phase, resulted in maximum B:C ratio (3.54). Hence, these treatments are recommended for commercial cultivation of chrysanthemum cultivars 'Purnima' and 'Pusa Shwet' for cut flower production.

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## APPENDIX-I

**Mean monthly meteorological data of Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) for the year 2019-2020 (w.e.f. June, 2019 to February, 2020)**

| Months          | Temperature (°C) |              |           | Relative Humidity (%) | Rainfall (mm) |
|-----------------|------------------|--------------|-----------|-----------------------|---------------|
|                 | Maximum (°C)     | Minimum (°C) | Mean (°C) |                       |               |
| June, 2019      | 33.70            | 17.80        | 25.75     | 48.00                 | 98.50         |
| July, 2019      | 27.70            | 19.90        | 23.82     | 79.00                 | 218.10        |
| August, 2019    | 28.80            | 20.10        | 24.45     | 79.00                 | 225.80        |
| September, 2019 | 28.30            | 18.60        | 23.45     | 78.00                 | 151.40        |
| October,2019    | 25.60            | 11.30        | 18.45     | 66.00                 | 5.60          |
| November,2019   | 22.80            | 8.10         | 15.45     | 61.00                 | 32.20         |
| December,2019   | 19.10            | 1.90         | 10.50     | 58.00                 | 33.20         |
| January,2020    | 15.70            | 2.50         | 9.10      | 68.00                 | 168.30        |
| February,2020   | 20.20            | 4.10         | 12.15     | 57.00                 | 38.50         |

**Source:** Meteorological Observatory, Department of Environmental Science, College of Forestry, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP)  
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## APPENDIX –II

**Analysis of variance (ANOVA) for different parameters as influenced by effect of N, P and K application at different stages in chrysanthemum**

| Source of Variation  | Degree of freedom | Mean Sum of Squares (MSS) |                   |                                       |                                    |
|----------------------|-------------------|---------------------------|-------------------|---------------------------------------|------------------------------------|
|                      |                   | Plant height (cm)         | Plant Spread (cm) | Days taken for flowers bud appearance | Days taken for flowers bud opening |
| Replications         | 2                 | 4.91                      | 2.35              | 7.97                                  | 13.76                              |
| Cultivars            | 1                 | 5578.20                   | 114.43            | 1329.34                               | 570.22                             |
| Treatments           | 4                 | 26.89                     | 35.50             | 5.29                                  | 11.00                              |
| Cultivars×Treatments | 4                 | 30.24                     | 56.55             | 6.37                                  | 32.09                              |
| Error                | 18                | 1.61                      | 46.96             | 2.41                                  | 8.97                               |

| Source of Variation  | Degree of freedom | Mean Sum of Squares (MSS) |                      |                  |
|----------------------|-------------------|---------------------------|----------------------|------------------|
|                      |                   | Days taken to flowering   | Flower diameter (cm) | Shoots per plant |
| Replications         | 2                 | 8.63                      | 0.89                 | 0.58             |
| Cultivars            | 1                 | 2778.33                   | 77.96                | 20.50            |
| Treatment            | 4                 | 5.00                      | 0.36                 | 0.58             |
| Cultivars×Treatments | 4                 | 7.13                      | 1.21                 | 0.33             |
| Error                | 18                | 2.26                      | 0.62                 | 0.55             |

| Source of Variation  | Degree of freedom | Mean Sum of Squares (MSS)       |                              |                  |
|----------------------|-------------------|---------------------------------|------------------------------|------------------|
|                      |                   | Weight of flowers per plant (g) | Duration of flowering (days) | Vase life (days) |
| Replications         | 2                 | 2.35                            | 0.15                         | 1.32             |
| Cultivars            | 1                 | 18291.86                        | 174.73                       | 38.51            |
| Treatments           | 4                 | 54.10                           | 3.58                         | 4.06             |
| Cultivars×Treatments | 4                 | 17.00                           | 8.22                         | 3.94             |
| Error                | 18                | 9.10                            | 1.31                         | 0.84             |

| Source of Variation  | Degree of freedom | Mean Sum of Squares (MSS)            |                            |                              |
|----------------------|-------------------|--------------------------------------|----------------------------|------------------------------|
|                      |                   | Number of suckers produced per plant | Available Nitrogen (kg/ha) | Available Phosphorus (kg/ha) |
| Replications         | 2                 | 24.63                                | 168.96                     | 58.88                        |
| Cultivars            | 1                 | 2.13                                 | 0.04                       | 0.96                         |
| Treatments           | 4                 | 66.62                                | 24.13                      | 3.03                         |
| Cultivars×Treatments | 4                 | 10.88                                | 16.26                      | 1.39                         |
| Error                | 18                | 5.45                                 | 125.67                     | 4.12                         |

| Source of Variation  | Degree of freedom | Mean Sum of Squares (MSS)   |       |           |                  |
|----------------------|-------------------|-----------------------------|-------|-----------|------------------|
|                      |                   | Available potassium (kg/ha) | pH    | EC (dS/m) | Organic carbon % |
| Replications         | 2                 | 24.63                       | 0.006 | 0.003     | 0.0005           |
| Cultivars            | 1                 | 2.13                        | 0.003 | 0.001     | 0.00             |
| Treatments           | 4                 | 66.62                       | 0.008 | 0.001     | 0.002            |
| Cultivars×Treatments | 4                 | 10.88                       | 0.002 | 0.001     | 0.00             |
| Error                | 18                | 5.45                        | 0.001 | 0.001     | 0.001            |

**Department of Floriculture and Landscape Architecture**  
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**Title of the Thesis** : “Effect of N, P and K application at different stages in chrysanthemum (*Chrysanthemum morifolium* Ramat)”  
**Name of the Student** : Deachen Dolma  
**Admission Number** : H-2018-105-M  
**Major Discipline** : Floriculture and Landscape Architecture  
**Minor Discipline** : Soil Science and Water Management  
**Date of Thesis Submission** :  
**Total Pages of the Thesis** : 73+iii  
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**No. of words in Abstract** : 246

**ABSTRACT**

The present investigation entitled “Effect of N, P and K application at different stages in chrysanthemum (*Chrysanthemum morifolium* Ramat)” was carried out at Research Farm of Department of Floriculture and Landscape Architecture, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) - 173 230 during the year 2019-2020 to find out the effect of phenophase based application of N, P and K for production of quality flowers in chrysanthemum. Two cultivars with five treatments consisting of N, P and K were applied through basal dose as well as drench method at different growth phases i.e. vegetative, bud and flowering phase. Field experiment was laid out in a Randomized Block Design (RBD) with three replications. Maximum plant height (57.87 cm), plant spread (27.55 cm), minimum number of days for flower bud appearance (97.92 days) and minimum days to flowering (140.91 days) were recorded in plants which received treatment T<sub>4</sub> {40:20:20 % NPK (Vegetative phase), 30:40:40 % NPK (Bud phase), 30:40:40 % (Flowering phase) @ 75:112.5:75 kg NPK/ha}. While, flower diameter (8.53 cm), number of shoots per plant (3.72), weight of flowers per plant (50.01 g), duration of flowering (25.77 days) and number of suckers produced per plant (15.33) were recorded maximum in T<sub>5</sub> {33.3:33.3:33.3 % NPK (Vegetative phase), 33.3:33.3:33.3 % NPK (Bud phase), 33.3:33.3:33.3 % NPK (Flowering phase) @ 100:150:100 kg NPK/ha}. The treatment T<sub>3</sub> in cultivar ‘Purnima’ having B:C ratio of (4.06) is more profitable as compared to ‘Pusa Shwet’ (3.54) in T<sub>2</sub>.

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