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# Assessment of nitrogen fertigation and plant spacing in chrysanthemum (*Chrysanthemum morifolium* Ramat.) cv. Ratlam selection

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**Abstract**

For high quality loose flower production, the study aimed to standardize plant spacing and fertigation, the study "Studies on plant spacing and fertigation schedule for loose flower production of chrysanthemum (*Chrysanthemum morifolium* Ramat.)" was conducted from 2021 to 2022 at Research farm, Department of Floriculture & Landscaping and Soil and Water Engineering, Punjab Agricultural University, Ludhiana.

There were four different levels of fertigation N @ (60 kg/ha, 80 kg/ha, 100 kg/ha and 120 kg/ha) were applied to chrysanthemum varietiy namely 'Ratlam Selection' through drip irrigation along with three different spacing levels i.e., 40×30 cm, 40×40 cm and 40×60 cm. Split Plot Design (SPD) was the statistical method employed, and the trial was repeated three times.

Data on growth, flowering and yield factors were collected and statistically analysed. The data observed on growth and floral attributes, i.e., number of branches (7.80), plant spread (46.70), flower weight (3.22 gm), maximum chlorophyll content least days to flower bud initiation (82.92 days), flower weight (3.22 gm) and highest chlorophyll content (58.57 spad value) was recorded with the application of N @ 120 kg/ha$^{-1}$ with planting distance of 40×60 cm and the maximum flower diameter (7.71 cm) and number of flowers per plant (138.67) were recorded higher with the application of N @ 100 kg/ha$^{-1}$ with planting distance of 40×60 cm. Yield attributes such as total flowers weight per unit area (m$^2$), number of flowers per unit area (m$^2$), were recorded best with treatment N @ 100 kg/ha with plant spacing 40×60 cm. The research's findings indicate that the best fertigation for producing high-quality loose chrysanthemum flowers, with a spacing of 40×60 cm, and fertigation N @ 100 kg/ha."

**Keywords:** Chrysanthemum, fertigation, irrigation, nitrogen and spacing levels

## Introduction

"India's culture and history have always been closely associated with flowers. Flowers are nature's most exquisite creation, capable of enchanting anyone with joy, love, and pleasure. Today, the global floriculture business is thriving in terms of both production and commerce.

The floriculture business is booming globally in terms of both production and trade these days. The word 'Chrysanthemum' is originated from the two Greek words '*Chryos'* meaning gold and '*Anthemon'* means 'flower' and completely 'Golden Flower'. Commonly it is known as 'Gul-e-daudi', 'Autumn Queen' and 'Queen of the East', belonging to family 'Asteraceae' and native of Asia and northern hemisphere especially Europe (Choudhary *et al.* 2021) [4]. Due to its great variation in terms of bloom color and tone, shape and size, growth pattern, age group, and post-harvest quality characteristics, this flower crop is farmed commercially around the world.

This crop is said to have been cultivated for the first time in China, after which it spread to Japan and other countries. Chrysanthemums with yellow and white colours are traditionally produced for loose flowers, which are then utilized for worship and garland-making. Chrysanthemum varieties are divided into two classes on the basis of size *viz*., spray and standard type. While standards are used for indoor vase decoration, cut flower production, bouquet and flower arrangement making, and pot plants for both outdoor as well as indoor decoration and exhibition purposes, spray types are typically grown for loose flower purposes, such as social ceremonies, worship, and garland making.

In addition to its remarkable beauty, a broad variety of colors, sizes, shapes, and bloom retention qualities, together with its ease of propagation, have increased its appeal to both commercial producers and consumers (Bisht *et al.* 2010) [3]. There is a year-round demand for these flowers during the festive seasons, parties, and décor. Variety 'Ratlam Selection' is a mid- to late-season cultivar with a spreading growth pattern. The cream-colored flowers are beautiful in nature and suitable for loose flower production.

There is a dearth of scientific data regarding enhanced agro-techniques for the productive growing of chrysanthemums, and farmers are unable to increase their profit margin per acre. Nutrition and plant spacing are the two major factors that adversely affects the growth and flower yield. (Satar *et al*. 2016) [13] Lack of technical knowledge and better agro-techniques, such as fertilizer dosage, are causing growers to struggle with the scientific growth of chrysanthemums. Nowadays, the soil health is also diminishing due to excess

use of pesticides, fertilizers and insecticides and other factor like repeated plantation of same crop over again and again in the same field. Inappropriate nutrient management leads to nutrient imbalance in plants and causes stunted plant growth and results in decreasing flower yield (Senapati *et al*. 2020) [16]. Nitrogen played an important role on growth of plants and also regarded to be one of the important component for vegetative growth and flower yield in chrysanthemum (Rajan *et al.* 2019) [11]. In order to maximize production, nitrogen plays a crucial role in the plant by ensuring that energy is available for growth at the right time and location.

In present situations, lessened flower yield and poor quality of flowers is mainly due to inappropriate use of fertilizers. Chrysanthemum is a shallow rooted crop and proper nutrient management as well as maintenance of proper available moisture level in the soil is essential to compensate the evapo-transpiration losses and economic losses. Therefore, micro irrigation system can be used to manage these kind of losses. Drip irrigation is most effective technology and can be used on a wide range of crops. (Solaimalai *et al*. 2005) [17] Since water is applied directly to a crop's root zone by drip irrigation, this is the most successful technique available and one of the most cost-effective options for high-value crops.

Yes, it is well recognized that the most practical and effective approach to maintain the optimum fertility level in soil and consistent water supply in accordance with soil requirement and crop is through fertilization, which combines fertilizers application and irrigation. Drip irrigations allows for precise nutrient supply to plants because nutrients are directly applied to the root zone of plants (Neilsen *et al.* 2004) [10]. Another factor spacing between plants also plays significant role that also effects development and growth of plants. Plant population allows plants significantly use of nutrients, sunshine and water more efficiently and effects vegetative and reproductive growth (Sahu *et al.* 2021) [12]. A plant's competition for nutrients and other inputs may increase due to closer spacing between plants, which can impact blossom yield and quality characteristics of flowers. Lesser flower yield is mainly due to insufficient number of plants per unit area due to widely spaced plants. Appropriate plant spacing and balanced use of fertilizers are necessary for better plant spread growth and yield. Plants planted at optimum spacing creates a favourable atmosphere for plants and hence, results in better flower yield (Ahirwar *et al.* 2012) [1]. As a result, yet it was unknown how to manage nitrogen level plant spacing for better growth and productivity of Chrysanthemum.

**The study's goals were as follows**

1. To achieve uniformity in the amount of nitrogen needed for high-quality loose flower production in chrysanthemum plants by using drip irrigation.
2. To achieve consistency in optimum plant spacing for the production of high quality loose flowers.

## Materials and Methods

### Field site

"During 2020-21 a field experiment was conducted at Floriculture & Landscaping Experimental Station of Punjab Agricultural University (Latitude 30·9 $^0$ N & Longitude of 75.85$^0$E), Ludhiana. The climate in this area was humid sub-tropical, hot during summer (April to June), humid (July to Sept.) and chilly (Dec. to Jan.) with ground frost. The soil texture is light sandy loam. Before, the experiment, the top layer of soil 0–20 cm contained available N 170.60 kg/ha, available P 20.40 kg/ha and available K 155.50 kg/ha and soil pH was 7.25."

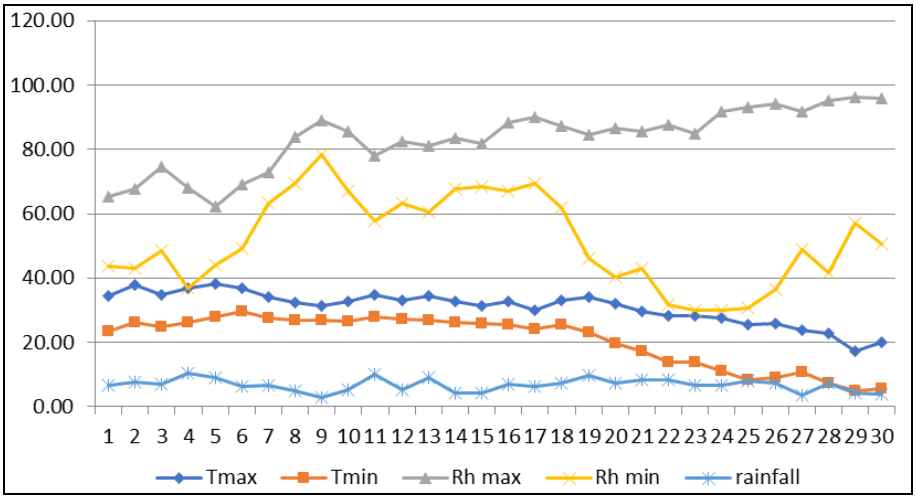


**Fig 1:** Rainfall, relative humidity, max temperature and mini temperature during the growing season of chrysanthemum cv. 'Ratlam selection'

### Experimental design

A split plot design was carried out. There are four different Nitrogen fertigation levels i.e. (N1 60 kg/ha), (N2 80 kg/ha), (N3 100 kg/ha) and (N4 100 kg/ha) with three spacing levels (S1 40×30 cm), (S2 40×40 cm) and (S3 40×60 cm) and were replicated thrice.

Total 16 Nitrogen fertigations were applied at interval of 4 days and irrigation was applied at interval of 2 days.

The chrysanthemum variety was "Ratlam Selection". Seedlings were transplanted into the field in the first week of August. Plot dimensions were 8 m$^2$ (10×0.8 m).

## Results

### Vegetative characteristics

"Increased nitrogen fertigation level and plant spacing had a substantial impact on the vegetative parameters of the chrysanthemum cultivar "Ratlam selection," including plant height, plant spread, branches/plant, and chlorophyll content (spad value). Treatment $T_{10}$ (N4S1) had the highest average plant height (56.78 cm), followed by $T_7$ (N3S1) (54.95 cm). Treatment $T_{12}$ (N4S3) had the highest plant spread (46.70 cm), followed by $T_9$ (N3S3) (46.04 cm), and treatment $T_1$ (N1S1) had the lowest average plant spread (34.99 cm). The highest number of branches (7.80) was recorded in treatment $T_{12}$ ($N_4S_3$) which was at par with $T_{11}$ ($N_4S_2$) and lowest number of branches (6.00) was observed in treatment $T_1$ ($N_1S_1$) followed by number of branches (6.13) in treatment $T_1$ ($N_1S_1$). Treatment $T_{12}$ (N4S3) had the highest chlorophyll content (58.57 spad value), while treatment $T_1$ (N1S1) had the lowest (45.20 spad value)."

**Table 1:** Effect of different fertigation levels and plant spacing on Vegetative characteristics of Chrysanthemum cv. 'Ratlam selection'

Effect of different nitrogen

| Treatments | Plant height (cm) | Plant spread (cm) | Number of branches | Chlorophyll content (Spad value) |
|---|---|---|---|---|
| $T_1$ ($N_1S_1$) | 47.73 | 34.99 | 6.00 | 45.20 |
| $T_2$ ($N_1S_2$) | 47.73 | 35.81 | 6.13 | 46.67 |
| $T_3$ ($N_1S_3$) | 48.10 | 35.80 | 6.53 | 47.10 |
| $T_4$ ($N_2S_1$) | 49.17 | 35.88 | 6.60 | 48.73 |
| $T_5$ ($N_2S_2$) | 48.54 | 37.47 | 6.80 | 50.00 |
| $T_6$ ($N_2S_3$) | 50.69 | 38.73 | 7.13 | 50.10 |
| $T_7$ ($N_3S_1$) | 54.95 | 41.99 | 7.27 | 55.13 |
| $T_8$ ($N_3S_2$) | 54.26 | 42.23 | 7.40 | 55.47 |
| $T_9$ ($N_3S_3$) | 54.87 | 46.04 | 7.73 | 57.93 |
| $T_{10}$ ($N_4S_1$) | 56.78 | 43.03 | 7.67 | 56.20 |
| $T_{11}$ ($N_4S_2$) | 54.74 | 45.46 | 7.77 | 57.83 |
| $T_{12}$ ($N_4S_3$) | 54.03 | 46.70 | 7.80 | 58.57 |

### Floral characteristics

"The flowering parameters included flower diameter, flower weight, days to first flower bud initiation, number of flowers per plant and total yield. The observations recorded on different flowering parameters were given in table 2.

During the 2020-21 year of experimentation, significantly an early flower bud initiation (82.92 days) was noticed with application of N @ 120 kg/ha with plant spacing 40×60cm however, maximum days to first flower bud initiation from transplanting were recorded in the $T_1$ ($N_1S_1$) i.e. N @ 60 kg/ha with plant spacing 40×30 cm.

The treatment $T_9$ with application of N @ 100 kg/ha and plant spacing 40×60 cm had the largest flower diameter (7.71 cm), which was comparable to N @ 120 kg/ha and plant spacing 40×60 cm (7.61 cm). In comparison, treatment $T_1$ with N1S1 reported the lowest flower diameter (6.71 cm).

It was discovered that nitrogen worked best for boosting blossom weight. In $T_1$, the lowest flower weight (2.45 gm) was recorded with combination of N1S1, i.e. N @ 60 kg/ha and plant spacing 40×30 cm. The highest flower weight (3.22 gm) was recorded with combination of N @ 120 kg/ha with plants spaced at 40×60 cm, followed by (3.07 gm) with N @ 120 kg/ha with plant spacing 40×30 cm.

The effect of different nitrogen levels and plant spacing and their interaction was found to be significant on number of flowers per plant. Significantly maximum number of flowers/plant were recorded with higher nitrogen level under wider spacing. The treatment combination $N_3S_3$ i.e. N @ 100 kg/ha with plant spacing 40×30 cm recorded the highest number of flowers per plant (138.67), followed by $N_3S_2$ (135.52) and the lowest number of flowers per plant (105.82) was recorded in $T_1$ with combination application of N @ 60 kg/ha and plants planted at spacing 40×30 cm.

The N @ 100 kg/ha and plant spacing 40×30 cm had recorded significantly maximum flower yield (105.07 q/acre) which was followed by N @ 120 kg/ha and plant spacing 40×30 cm (97.67 q/acre) due to more number of plants/$m^2$. However, significantly minimum flower yield (40.02 q/acre) was recorded with in $T_3$ i.e. N @ 60 kg/ha with plant spacing 40×60 cm."

**Table 2:** Effect of different fertiagtion levels and plant spacing on floral characteristics of Chrysanthemum cv. 'Ratlam Selection'

| Treatments | Days to bud appearance (days) | Flower diameter (cm) | Flower weight (g) | Number of flowers | Total yield (q/acre) |
|---|---|---|---|---|---|
| $T_1$ ($N_1S_1$) | 87.08 | 6.71 | 2.45 | 105.82 | 70.64 |
| $T_2$ ($N_1S_2$) | 87.17 | 6.91 | 2.51 | 108.31 | 65.12 |
| $T_3$ ($N_1S_3$) | 86.83 | 7.12 | 2.58 | 110.66 | 40.02 |
| $T_4$ ($N_2S_1$) | 86.42 | 7.26 | 2.59 | 116.23 | 81.87 |
| $T_5$ ($N_2S_2$) | 86.33 | 7.29 | 2.72 | 119.02 | 66.80 |
| $T_6$ ($N_2S_3$) | 85.83 | 7.34 | 2.78 | 123.05 | 48.04 |
| $T_7$ ($N_3S_1$) | 85.50 | 7.26 | 2.97 | 129.95 | 105.07 |
| $T_8$ ($N_3S_2$) | 84.42 | 7.57 | 2.99 | 135.52 | 83.48 |
| $T_9$ ($N_3S_3$) | 84.25 | 7.71 | 3.04 | 138.67 | 59.13 |
| $T_{10}$ ($N_4S_1$) | 83.33 | 7.27 | 3.07 | 116.73 | 97.67 |
| $T_{11}$ ($N_4S_2$) | 83.33 | 7.55 | 3.06 | 120.93 | 76.24 |
| $T_{12}$ ($N_4S_3$) | 82.92 | 7.61 | 3.22 | 122.87 | 55.54 |

## Discussion

"Application of Nitrogen fertilizer is one of the most important cultivated practices to increase the loose flower production in chrysanthemum. Plant height is increased by closer plant spacing and higher nitrogen levels. Plants cultivated with a 40×30 cm spacing between each other reach their maximum height. This might could be because there is not enough space for the plants to spread out and there is active competition between the plants for light and air under closer spacing, which promotes higher vertical development. Similar results were also noted by (Jadhav *et al.* 2014) [6] in Canlendula. The highest plant height was noted under the application of N @ 100 kg/hectare followed with the application of N @ 120 kg per hectare due to rapidly and highest intake of nutrients and similar results were also recorded by (Satar *et al.* 2016) [13] with application of Nitrogen @ 120 kg/ha. Application of higher amount of nitrogen imparts dark green colours to plants and promotes vegetative growth of the plants. Similar findings were also reported by (Rajan *et al.* 2019) [11]. Plants showed significant results when they are planted at different spacing levels. Different levels of nitrogen were used to investigate variations in plant spread. Wider plant spacing may be the cause of this variation in plant spread since it creates favorable growing conditions for the development of roots and shoots, which in turn aid in increased nutrient uptake. Similar findings have also been observed in chrysanthemum by (Kedar *et al.* 2022) [8]. Plants grown at wider spacing @ 40×60 cm has highest number of branches/plant and the reason might be due to the sufficient space available for plants to spread and uptake of sufficient nutrients from the soil for widely spaced plants according to (Jadahv *et al.* 2014) [6] in calendula. Increase in number of branches at widely spaced plants, this might be due to the availability of nutrients during the different growth stages of plants through fertigation and similar results in chrysanthemum have also been reported by (Choudhary *et al.* 2021) [4]. Chlorophyll content in plants have been also increases as the application rate of fertilizers increases in soil. This might be due to the reason that nitrogen is essential constitute of chlorophyll and active participate in formation of amino acids. Similar findings were also reported by (Jawaharlal and Ganesh 2020) [5]. The least days taken by plants to first flower bud initiation (82.11 days) was recorded in plants grown with application of N @ 120 kg/ha. The positive effects of plants was recorded due to application of nutrients through drip irrigation on earliest bud appearance might be due to the reason that application of higher amount of nitrogen accelerates the reproductive phase of plants and hence results in earlier floral primordial development. (Choudhary *et al.* 2021) [4] similar findings were also reported in chrysanthemum. Application of Nitrogen fertilizer @ 100 kg/ha and followed by application of Nitrogen @ 120 kg/ha were recorded as the optimum doses for maximum flower diameter and flower weight and similar findings were also confirmed by (Satar *et al.* 2012) [14], due to increased photosynthetic activity that might be the cause for variation in flower diameter. Application of optimum Nitrogen dose to plants helps in better vegetative growth of plants and developed better quality of flowers. According to current finding plants planted at greater distance had flowers with the largest flower diameter and this could be might due to plants with wider spacing absorbs better and ideal of water and nutrients from the soil and receives ample light for improving photosynthetic activity and movement of assimilates into storage organs. These findings have been also confirmed by (Swetha *et al.* 2018) [18] in Asiatic Lilies. Flower weight also increased with the application of higher amount of Nitrogen. This might be due to the reason that higher amount of nitrogen accelerates the photosynthetic activity of plants, results in increased cell division and expansion of flower tissue and results in increased weight of flower. Similar results were also recorded by by (Joshi *et al.* 2013) [7] in chrysanthemum. Excessive vegetative growth, which can lead to reproductive growth, may be the cause of the variance in the number of flowers with varying nitrogen levels and planting distances. High nitrogen also seems to favor the formation of flowers. Higher level of nitrogen application produced the highest yield of flowers was also reported by (Satar *et al.* 2016) [13] in chrysanthemum and (Kumar *et al.* 2018) [9] in marigold. Since widely spaced plants have greater access to sunlight, nutrients, and soil moisture, it is possible that the wider spacing has led to higher vegetative growth of the plants, which in turn has produced more blooms per plant."

(Jadhav *et al.* 2014) [6] also recorded the similar findings when plants planted at wider spacing 30×30 cm in calendula. These findings were also got the support from other scientist in chrysanthemum such as (Sahu *et al.* 2021) [12]. Treatment receiving Nitrogen @ 100 kg/ha results in higher yield of chrysanthemum flowers. Similarly increases in flower yield due to application of higher amount of Nitrogen (150 kg N/ha). Similar findings were also recorded by (Sehrawat *et al.* 2003) [15] and by (Baboo *et al.* 2005) [2] in African Marigold.

## Conclusion

"The interaction effect of different nitrogen application levels and plant spacing showed significant results. The data was recorded plant spread (46.70 cm), number of branches (7.80), least days to first flower bud initiation (82.92 days), flower weight (3.22 gm) and highest chlorophyll content (58.57 spad value) with the application of N @ 120 kg/ha with spacing 40×60 cm and largest flower diameter (7.71 cm) and highest number of flowers (138.67) was recorded with the application of N @ 100 kg/ha with spacing 40×60 cm. Yield parameters such as number of flowers per unit area ($m^2$), highest flower weight and highest flower yield ($m^2$) was recorded best with the application of Nitrogen @ 100 kg/ha with plant spacing 40×30 cm. The findings of the study shows that the best fertigation level and plant spacing for producing high quality loose flowers was N @ 100 kg/ha with 40x30."

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