AATCC Review

03 February 2025: Received
02 April 2025: Revised
07 April 2025: Accepted
10 May 2025: Available Online

https://aatcc.peerjournals.net/

Original Research Article | Open Access

Various Irrigation and Fertigation Management Practices on Flower Quality, Cut Flower Yield and Soil Nutrient Status of Chrysanthemum (*Chrysanthemum Morifolium* Ramat.) Cultivars.

B. Gouthami[1], D. S Gurjar[1], P. S Bramhanand[1], A. K. Tiwari[2], Mam Chand Singh[3], Subhash Babu[4], Shiv Prasad[5], Jitendra Rajput[6]

[1]*Water Technology centre, ICAR- Indian Agricultural Research Institute, New Delhi-110012, India*
[2]*Division of Floriculture and Landscaping, ICAR-Indian Agricultural Research Institute, New Delhi-110012, India.*
[3]*Division of Floriculture and Landscaping -CPCT, ICAR-Indian Agricultural Research Institute, New Delhi-110012, India*
[4]*Division of Agronomy, ICAR- Indian Agricultural Research Institute, New Delhi -110012, India*
[5]*Division of Environment Science, ICAR- Indian Agricultural Research Institute, New Delhi-110012, India*
[6]*Division of Agricultural Engineering, ICAR- Indian Agricultural Research Institute, New Delhi-110012, India*

ABSTRACT

The consistency of floral pigmentation, along with optimal soil nutrient supplementation, plays a key role in determining flower colour and underscores the importance of improving inflorescence traits, yield, and soil nutrient status in chrysanthemum cultivation. Keeping in view a field experiment was carried out during the rabi seasons of 2023–24 and 2024–25 at the Precision Farming Development Centre (PFDC), Water Technology Centre, at ICAR-IARI, New Delhi. The research focused on investigating the impact of various irrigation and fertigation management practices on flower quality, cut flower yield and soil nutrient status of chrysanthemum (Chrysanthemum morifolium ramat.) cultivars. The experiment was laid out in a split-split plot design with three factors: two cultivars (autumn pink and autumn white), three irrigation levels (0.5 Epan, 0.75 Epan and 1.0 Epan), and three fertigation schedules (50%, 75%, and 100% recommended dose of fertilizers). Based on the Royal Horticultural Society (RHS) Colour Chart classification, the Autumn Pink (V1) variety consistently exhibited 65 C (Pale Purplish Pink) across all irrigation and fertigation levels, while Autumn White (V2) maintained 157 D (Greenish White). The observed stability in flower colour suggested that genetic factors primarily control floral pigmentation, with minimal environmental influence under the applied treatments. Similarly, the treatment combination V2I2F3 (Autumn White + Irrigation at 0.75 Epan + 100% RDF) consistently achieved the highest number of cut flowers per ha (i.e 488,975.21 flowers/ha), hence resulting in higher gross returns, net returns and overall profitability. Pertaining to soil physical and chemical parameters the pH was 7.65 with 0.29 dS m^{-1} EC and 0.43% organic carbon, 125.66 kg/ha, 26.55 kg/ha and 281,41 kg/ha available N, P_2O_5 and K_2O, suggested that optimum supplementation of nutrients were essential to improve the inflorescence traits, yield and soil nutrient status of chrysanthemum.

Keywords: *Drip Fertigation, autumn white and pink cultivars, flower quality, flower yield, soil nutrient status*

INTRODUCTION

Chrysanthemum (*Chrysanthemum morifolium* Ramat.) is a valuable commercial flower crop grown for its attractive flowers all over the world. It is commonly known as Guldaudi, "Queen of the East" & "Glory of the East". The demand for chrysanthemum flowers in India exists in big metropolitan cities like Delhi, Kolkata, Mumbai, Bangalore, Coimbatore etc. Asia Pacific has the the largest production area for cut flowers and pot plants which is around 4.68 lakh ha (Anonymous, 2019). Chrysanthemum flowers can be classified into two categories on the basis of size viz., spray and standard type. The spray types are usually grown for loose flower purposes i.e., for social ceremonies, worship purposes, and garland making, whereas, standards are used for cut flower production, indoor vase decoration, and making bouquets and flower arrangements.

Corresponding Author: **B. Gouthami*

DOI: https://doi.org/10.21276/AATCCReview.2025.13.02.474

Apart from its exceptional beauty, the wide range of colour, size, shape and quality of flowers, easy to propagate have also made it much more popular among consumers and commercial growers (Bisht *et al*., 2010). The demand for chrysanthemums reached 35% of the overall market request, second only to roses (Steen, 2010). The successful cultivation of chrysanthemums depends on the selection of suitable varieties, therefore, the evaluation of suitable varieties for a particular region is considered important.

Drip irrigation has proven to be an efficient technique for applying water-soluble nutrients through fertigation. This method achieves up to 90% irrigation efficiency, increases crop yield by 25-30%, and conserves 30-50% of irrigation water compared to conventional irrigation techniques. The first extensive comparison of drip irrigation with the conventional form of irrigation was made by Goldberg and coworkers under severely limiting environmental conditions in the Arava and Negev districts of Israel, where an average yield of more than 75 per cent was observed in the case of pepper, tomato crops (Goldberg and Shumeli, 1971). However its adequate handling has been neglected by growers, resulting in growing loss and consequent productivity and quality decreases in the final product (Farias *et al*., 2009). The application of fertilizers through irrigation will supply and maintain an optimum level of nutrients within the root zone. Fertigation improves fertilizer use efficiency, saves fertilizers, time and labour and also helps in uniform and precise application of nutrients in the effective root zone resulting in higher and quality production of flowers. Keeping the above facts in view and to bridge the knowledge gap on productivity and quality of chrysanthemums under varied nutrients and drip irrigation regimes, the present study has been planned.

MATERIALS AND METHODS

The study was carried out during the winter *rabi* seasons of 2023–24 and 2024–25 at the Precision Farming Development Centre (PFDC), Water Technology Centre, ICAR-Indian Agricultural Research Institute (28° 63' N and 77° 16' E, altitude of 230 meters AMSL), New Delhi (Fig 1). In the experiment, a split-split plot design was used with 18 treatments in total and each treatment was replicated thrice. These treatments included two cultivars (autumn pink and autumn white), three irrigation schedules (0.5 Epan, 0.75 Epan and 1.0 Epan) and three fertigation schedules (50%, 75%, and 100% recommended dose of fertilizers). The treatment details are shown in (Table 1).

Table 1. Details of Total Treatments in Combinations

S. No.	Treatments	Treatment Detail	Label Symbol
1.	T_1	Autumn pink + Irrigation Scheduled at 0.5 Epan + 50% RDF	$V_1I_1F_1$
2.	T_2	Autumn pink + Irrigation Scheduled at 0.5 Epan + 75% RDF	$V_1I_1F_2$
3.	T_3	Autumn pink + Irrigation Scheduled at 0.5 Epan + 100% RDF	$V_1I_1F_3$
4.	T_4	Autumn pink + Irrigation Scheduled at 0.75 Epan + 50% RDF	$V_1I_2F_1$
5.	T_5	Autumn pink + Irrigation Scheduled at 0.75 Epan + 75% RDF	$V_1I_2F_2$
6.	T_6	Autumn pink + Irrigation Scheduled at 0.75 Epan + 100% RDF	$V_1I_2F_3$
7.	T_7	Autumn pink + Irrigation Scheduled at 1.0 Epan + 50% RDF	$V_1I_3F_1$
8.	T_8	Autumn pink + Irrigation Scheduled at 1.0 Epan + 75% RDF	$V_1I_3F_2$
9.	T_9	Autumn white + Irrigation Scheduled at 1.0 Epan + 100% RDF	$V_1I_3F_3$
10.	T_{10}	Autumn white + Irrigation Scheduled at 0.5 Epan + 50% RDF	$V_2I_1F_1$
11.	T_{11}	Autumn white + Irrigation Scheduled at 0.5 Epan + 75% RDF	$V_2I_1F_2$
12.	T_{12}	Autumn white + Irrigation Scheduled at 0.5 Epan + 100% RDF	$V_2I_1F_3$
13.	T_{13}	Autumn white + Irrigation Scheduled at 0.75 Epan + 50% RDF	$V_2I_2F_1$
14.	T_{14}	Autumn white + Irrigation Scheduled at 0.75 Epan + 75% RDF	$V_2I_2F_2$
15.	T_{15}	Autumn white + Irrigation Scheduled at 0.75 Epan + 100% RDF	$V_2I_2F_3$
16.	T_{16}	Autumn white + Irrigation Scheduled at 1.0 Epan + 50% RDF	$V_2I_3F_1$
17.	T_{17}	Autumn white + Irrigation Scheduled at 1.0 Epan + 75% RDF	$V_2I_3F_2$
18.	T_{18}	Autumn white + Irrigation Scheduled at 1.0 Epan + 100% RDF	$V_2I_3F_3$

The experimental soil was classified as sandy loam, consisting of 71% sand, 14% silt, and 15% clay. It had a pH of 7.65, an electrical conductivity of 0.29 dS/m, and an organic carbon content of 0.43%. The available nutrient levels of nitrogen (N), phosphorus (P), and potassium (K) were recorded at 125.66, 26.55, and 281.41 kg/ha, respectively. Soil moisture content was measured at 24.3% at field capacity and 7.3% at the permanent wilting point. The experimental plots were measured as 3 m × 1 m, with drip emitters spaced 30 cm apart. The field was divided into two main plots, separated by 2 m, and further subdivided into sub-plots and sub-sub-plots. Healthy, disease-free seedlings, aged 45 days, were transplanted to the field on July 24th in both 2023-24 and 2024-25. Irrigation was carried out every third day based on daily evaporation values collected from a USWB Class 'A' pan evaporimeter at the agrometeorological station, IARI, New Delhi. The amount of irrigation was calculated in terms of gross irrigation requirements and pumping time per application, whereas irrigation time is dependent on crop evapotranspiration (ET_c) on a daily basis. The duration of irrigation was determined by considering the number of laterals, emitter spacing, and emitter discharge for a given area. The drip irrigation system was maintained at a discharge rate of 4 re litres per hour and the fertilizers in the form of urea, DAP and MOP were applied in 3 equal splits at the Vegetative stage, Budding and Flowering stages Fertigation was given through a c century system on every 3rd day as per the treatment.

Biometric measurements of growth and flower parameters were recorded for five selected plants in each plot, with average values reported.

Flower colour was estimated using the RHS flower colour chart based on the Royal Horticultural Society (RHS) Colour Chart classification and the number of cut flowers per ha was also calculated separately until the final collection. The data from the two-year study were analyzed using a three-factor analysis of variance (ANOVA) based on a split-split plot design, as recommended by Gomez and Gomez (1984). Standard statistical procedures were employed to compute the critical difference (CD) for treatment contrasts. The least significant difference at P=0.05 was determined to assess variations among the treatments.

RESULTS AND DISCUSSION

Soil physical physicochemical and chemical properties

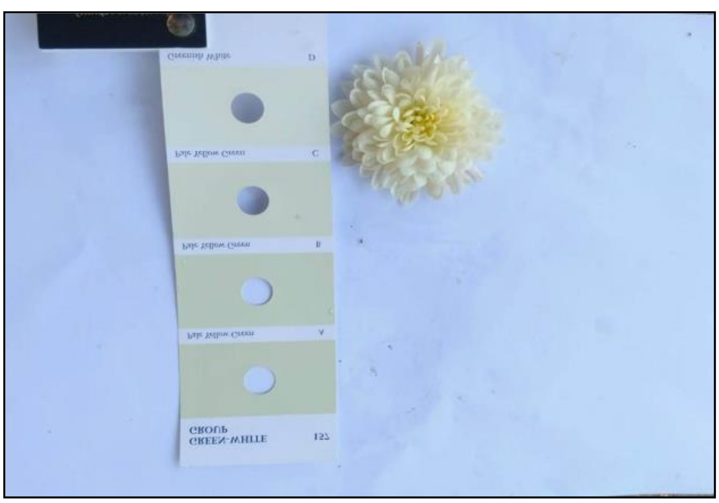
The physical, physico-chemical and chemical properties of soil in the experimental field are shown in Table 2. The soil texture analysis through the Bouyoucos Hydrometer method (Piper, 1966), revealed that the soil comprises 71% sand, 14% silt, and 15% clay, classifying it as sandy loam. The bulk density was recorded as 1.45 mg m^{-3}, indicating a well-structured soil with adequate porosity to support root growth. The available soil moisture content of 36.98 mm suggested that moderate water-holding capacity. The soil pH was found to be 7.65, with the electrical conductivity (EC) and organic carbon content of 0.29 dS m^{-1} and 0.43% suggested that moderate soil fertility. The available nitrogen, phosphorus (P_2O_5) and potassium (K_2O) contents were estimated as 125.66 kg ha^{-1}, 26.55 kg ha^{-1} and 281.41 kg ha^{-1} respectively, indicating that low nutrient levels, necessitating the optimal supplementation of nutrients essential for enhancing soil fertility and plant growth.

Table 2. Physical, physicochemical and chemical properties of soil in experimental field

S. No	Particulars	Value	Method adopted (Reference)
I.	Physical properties		
1.	Mechanical analysis		Bouyoucos hydrometer method (Piper, 1966)
	a) Sand (%)	71	
	b) Silt (%)	14	
	c) Clay (%)	15	
2.	Textural class	--	Sandy loam
3.	Bulk density (mg m-3)	1.45	(Dastane et al., 1972)
4.	Available soil Moisture [mm]	36.98	(Richards, 1949)
II.	Physico-chemical properties		
1.	pH (1:2.5 soil: water)	7.65	Make-Elico, Model- LI 612 pH analyser (Jackson, 1973)
2.	Electrical conductivity ($dS\ m^{-1}$)(1:2.5 soil: water)	0.29	SYSTRONIC Conductivity TDS meter 308 (Jackson, 1973)
3.	Organic carbon (%)	0.43	Walkley and Black's modified method (Jackson, 1967)
III.	Chemical properties		
4.	Available Nitrogen ($kg\ ha^{-1}$)	125.66	Alkaline permanganate method using KELPLUS SUPRA LX – analyser (Subbaiah and Asija, 1956)
5.	Available P_2O_5 ($kg\ ha^{-1}$)	26.55	Olsen's method for extraction and Ascorbic acid method for estimation by using UV-VIS Spectrophotometer (Make-systronics, Model-108) at 420 nm (Olsen's *et al.*, 1954)
6.	Available K_2O ($kg\ ha^{-1}$)	281.41	Neutral normal ammonium acetate method using (Make- Elico, Model- CL361), Flame photometer (Piper, 1966)

Table 3. Flower Colour (RHS Flower Colour Chart) Values and Cut Flower Yield (ha) as Influenced by Different Cultivars, Irrigation Levels and Fertigation Regimes During 2023–2024, 2024–2025.

Treatment	RHS Flower colour chart values	No. of cut flowers per ha
$V_1I_1F_1$	65 C (Pale Purplish Pink)	301977.97
$V_1I_1F_2$	65 C (Pale Purplish Pink)	343539.62
$V_1I_1F_3$	65 C (Pale Purplish Pink)	350179.35
$V_1I_2F_1$	65 C (Pale Purplish Pink)	363616.73
$V_1I_2F_2$	65 C (Pale Purplish Pink)	384090.78
$V_1I_2F_3$	65 C (Pale Purplish Pink)	406042.14
$V_1I_3F_1$	65 C (Pale Purplish Pink)	368230.44
$V_1I_3F_2$	65 C (Pale Purplish Pink)	390411.49
$V_1I_3F_3$	65 C (Pale Purplish Pink)	429831.85
$V_2I_1F_1$	157 D (Greenish white)	339901.69
$V_2I_1F_2$	157 D (Greenish white)	347467.26
$V_2I_1F_3$	157 D (Greenish white)	361705.64
$V_2I_2F_1$	157 D (Greenish white)	370432.43
$V_2I_2F_2$	157 D (Greenish white)	457500.33
$V_2I_2F_3$	157 D (Greenish white)	488975.21
$V_2I_3F_1$	157 D (Greenish white)	380890.10
$V_2I_3F_2$	157 D (Greenish white)	466916.75
$V_2I_3F_3$	157 D (Greenish white)	479229.25



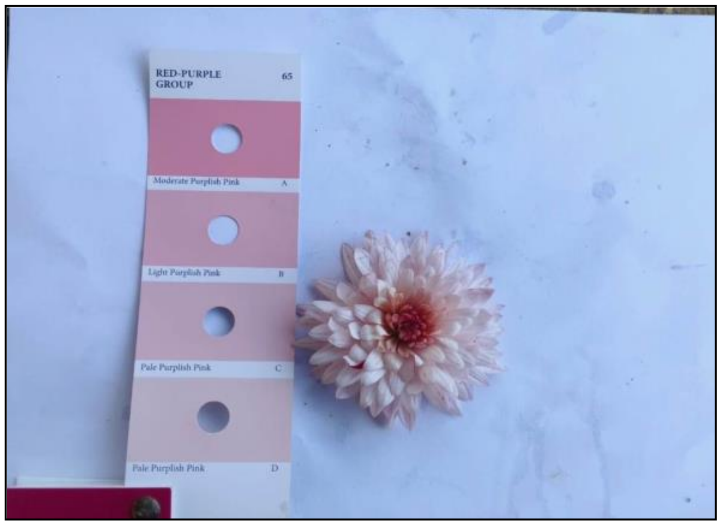


Fig 1. Flower colour (RHS Flower Colour Chart) showing the different groups for autumn white and autumn pink cultivars during 2023–2024, and 2024–2025

Flower colour variation by RHS flower colour chart

The analysis of flower colour across different treatments over two consecutive years (2023-24 and 2024-25) demonstrated remarkable stability (Table 3 and Fig 1). The variety Autumn Pink (V1) consistently exhibited 65 C (Pale Purplish Pink) across all irrigation and fertigation levels, while Autumn White (V2) maintained 157 D (Greenish White). Two distinct flower colour variations were observed based on the Royal Horticultural Society (RHS) Colour Chart classification. Variety V1 exhibited a pale purplish-pink flower colour (RHS 65 C) across all treatment conditions, whereas variety V2 displayed a greenish-white hue (RHS 157 D). The observed stability in flower colour suggests that genetic factors primarily control floral pigmentation, with minimal environmental influence under the applied treatments. Previous studies have shown that flower colour is determined by anthocyanin and flavonoid content, which remain relatively stable under varying fertilization and irrigation conditions (Zhao *et al.,* 2019; Smith *et al.,* 2020).

Similar findings were also reported by Kumar *et al.,* 2021 and Zhang *et al.,* 2021.

Cut flower yield (ha)

The cut flower yield from (Table 3.) varied significantly between treatments, indicating that both irrigation and fertilization showed a positive impact on cut flower yield (ha). The highest productivity was observed under increased irrigation and fertilization conditions. V2 exhibited a higher yield potential compared to V1, Similar to V1, yield increased progressively with higher fertilizer levels under each irrigation condition. The treatment combination V2I2F3 (Autumn White + Irrigation at 0.75 Epan + 100% RDF) consistently achieved the highest number of cut flowers per ha (i.e 488,975.21 flowers/ha), hence resulting in higher gross returns, net returns and overall profitability. These results align with previous findings that irrigation and fertilization significantly impact cut flower yield (Kumar *et al.,* 2021). Optimal nutrient and water management are essential for maximizing floral production.

Conclusion

The variety Autumn Pink (V1) consistently displayed a flower colour of 65 C (Pale Purplish Pink) across all irrigation and fertigation levels, while Autumn White (V2) maintained a stable 157 D (Greenish White). This consistency in floral pigmentation indicated that genetic factors predominantly governed the flower colour, with minimal influence from environmental conditions under the treatments applied. In contrast, cut flower yield (per hectare) showed significant variation among treatments. The treatment combination V2I2F3 (Autumn White + Irrigation at 0.75 Epan + 100% RDF) consistently produced the highest number of cut flowers per hectare (488,975.21 flowers/ha), resulting in the highest gross returns, net returns, and overall profitability across both the years and pooled data. Regarding soil physical and chemical properties, the pH was 7.65, with an electrical conductivity (EC) of 0.29 dS m^{-1}, organic carbon content of 0.43%, available nitrogen at 125.66 kg/ha, phosphorus at 26.55 kg/ha, and potassium at 281.41 kg/ha highlighting the importance of optimal nutrient supplementation for enhancing inflorescence traits, yield, and soil nutrient status in chrysanthemum cultivation.

Author Contributions

Gouthami: Investigation, methodology and writing-original draft preparation.

Gurjar and Bramhanand: Supervision, conceptualization and visualization.

Gurjar, Tiwari, C Mam Chand Singh, Subhash Babu and Shiv Prasad: Scientific comments, writing reviewing and editing.

Jithender Rajput Rajput: Reviewing and editing. This article has been read and approved by all listed authors.

Future scope of the study

Future research can focus on optimizing irrigation and fertigation schedules specific to chrysanthemum growth stages and cultivars. Integration with climate-smart and precision agriculture tools may enhance efficiency and sustainability. Long-term studies are needed to assess soil health, economic viability, and environmental impact.

Acknowledgements

We are thankful to the Water Technology Centre, ICAR-Indian Agricultural Research Institute, New Delhi for the successful conduct of the experiment and for providing the necessary laboratory facilities.

Conflict of Interest

The authors declare there is no conflict.

REFERENCES

1. Anonymous, (2019). International Statistics Flowers and Plants 2013. AIPH-Union Fleurs 2013, 61, 165, The Netherlands.
2. Bisht D, Kumar A and Kumar P. (2010). Standardization of media composition for pot mum production in open field under Tarai conditions. Abstract book, *National Symposium on Life style Floriculture Challenges and Opportunities* 19-21.
3. Dastane, N. G., *et al*. (1972). Soil bulk density measurement techniques.
4. Farias M.F., De Saad J.CC, Denise M.C. (2009). Effect of soil-water tension on cut chrysanthemum floral quality and longevity. *Applied Research & Agrotechnology* 2(1): 141-145.
5. Goldberg, D., and Shumeli, M. (1971a). Sprinkle and trickle irrigation of green pepper in an arid zone. *Horticulture science*, 6: 559-562.
6. Goldberg, D., and Shumeli, M. (1971b). The effect of distance from the trickles on soil salinity growth and yield of seed corn in arid zone. *Horticulture science,* 6: 565-567.
7. Jackson, M. L. (1967&1973). *Soil Chemical Analysis*. Prentice Hall of India Pvt Ltd.
8. Kumar, R., Sharma, P., & Verma, S. (2021). Impact of Irrigation and Fertilization on Floriculture Yield: A Meta-Analysis*. International Journal of Agricultural Sciences, 12(4), 189-203.*
9. Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean. L.A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Department of Agriculture Circular. 939.
10. Piper, C. S. (1966). *Soil and Plant Analysis*. University of Adelaide Press.
11. Richards, L. A. (1949). Soil moisture availability determination. *USDA Agricultural Handbook, 60*, 1-20.
12. Smith, A., Zhang, L., & Chen, Y. (2020). Anthocyanin Accumulation and Stability in Flowering Plants Under Varying Environmental Conditions*. Plant Physiology and Biochemistry, 65(2), 112-121.*
13. Steen M. (2010). A world of flowers: Dutch flower market and the market of cut flowers. *Journal of Applied Horticulture,* 12: 113-121

14. Subbiah, B.V. and Asija, G.L. (1956). A rapid procedure for the estimation of availability nitrogen in soils. *Current Science.* 25:259-260.

15. Walkley, A., & Black, I. A. (1967). Soil organic carbon determination. *Soil Science, 37*(1), 29-38.

16. Zhang, Y., Li, H., & Wang, J. (2021). Environmental stability of floral pigmentation: A genetic perspective. *Plant Physiology and Biochemistry, 164*, 112-120.

17. Zhao, X., Li, H., & Wang, P. (2019). Flavonoid Biosynthesis and Its Role in Flower Pigmentation and Stress Tolerance. *Journal of Plant Biochemistry, 54(1), 77-90.*