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Studies on the effect of fertigation in greenhouse chrysanthemum

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Abstract
Investigations were carried out to study the effect of levels of fertigation on growth and yield of chrysanthemum cv. Punch. The experiment was conducted in a greenhouse with nine treatments and three replications. The treatments comprised of four fertigation levels without micronutrients [75, 100, 125 and 150 percent recommended dose of fertilizers *viz.,* 16:4:16 g NPK / m^2 /crop, and four fertigation levels with micronutrients (75, 100, 125 and 150 percent RDF with 0.2 percent micronutrient mixture as foliar spray) along with a check (without fertilizers). Fertigation levels had a significant influence on growth and yield parameters at three stages of growth. T_6 recorded highest plant height (60.57cm, 90.34 cm and 138.90 cm), number of leaves (28.70, 36.54 and 38.44), total leaf area (1003.17 cm^2, 1253.56 cm^2 and 1328.77 cm^2), days to harvest (95.74 days), flower stalk length (132.24 cm) and stem yield / m^2 (77.68). However, earlier days taken for bud appearance (45.08 days), the maximum number of flowers per stalk (15.55), increased unopened and opened flower bud circumference of 3.56 cm and 8.54 cm was recorded in T_7.

Keywords: fertigation, greenhouse chrysanthemum

Introduction
Chrysanthemum (*Dendranthema grandiflora* Tzvelev) is one of the commercial flower crops in India as well as in the world. Flowers are valued for its keeping quality, wide array of colours and forms, and ability to rehydrate after a long transportation. These qualities form the basis of many floral arrangements, mixed bouquets, and general decorations. Quality of flower is one of the important factors that determine its demand in both domestic as well as international markets. The importance of nutrition on growth, development, and production of quality flowers has been well known. 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. Though the chrysanthemum is one of the important cut flowers, its yield and quality of flowers are very low due to varied soil conditions and inappropriate application of flowers. Micronutrients are to be necessarily taken up by the plants from soil or supplemented through foliar application for good growth and yield of crops and maximizing the efficient use of applied N, P and K. In the absence of these micronutrients, the plants are known to suffer from physiological disorders which eventually lead to imbalanced growth and low yield (Ganesh and Kannan, 2013b) [11]. Hence there is a need to standardize the optimum dose of fertilizers to improve the growth and yield of greenhouse chrysanthemum. With these objectives, the present study was taken up in the commercial spray type variety Punch.

The experiment was laid out in a Randomized Block Design (RBD) with nine treatments and three replications each.

Treatments	Details of treatments
T_1	Check (without fertilizers)
T_2	75 % RDF @ 12 : 3 : 12 g NPK/m^2
T_3	100 % RDF @ 16 : 4 : 16 g NPK/m^2
T_4	125 % RDF @ 20 : 5 : 20 g NPK/m^2
T_5	150 % RDF @ 24 : 6 : 24 g NPK/m^2
T_6	T_2 + Foliar spray spray of 0.2 % EDTA chelated micronutrient mixture
T_7	T_3+ Foliar spray spray of 0.2 % EDTA chelated micronutrient mixture
T_8	T_4+ Foliar spray spray of 0.2 % EDTA chelated micronutrient mixture
T_9	T_5+ Foliar spray of 0.2 % EDTA chelated micronutrient mixture
From T_2-T_9 75% of P was given as soil application in the form of SSP	

Materials and Methods

The study was conducted in a naturally ventilated greenhouse in the farm of M/s Salem Green Plants Limited, Yercaud, Salem district to study the effect of levels of fertigation on growth and yield of spray chrysanthemum cv. Punch. The experiment was laid out in a Randomized Block Design (RBD) with nine treatments and three replications each.

The source of water-soluble fertilizers used are poly feed (19:19:19), calcium nitrate (15.5:0:0), and potassium nitrate (13:0:45) and 0.2 percent humic acid were also given through drip two times in a week to each treatment except the control. Micronutrient mixture containing Zn- 2.5%, Fe-2.0%, B-0.1%, Mg-4.0%, Mn-1.0% and Cu-0.1% were given as foliar spray in doses as per the schedule at fortnight intervals. The characteristics of greenhouse soil were also analyzed (Soil type: Sandy Clay Loam, pH: 5.5, EC(dsm^{-1}): 0.3, N – 526 kg ha^{-1}, P – 61.7 kg ha^{-1} & K – 332 kg ha^{-1}). 15 days old rooted cuttings of spray chrysanthemum were planted in raised soil beds [containing growing media consortia *viz.*, Coco peat 3 kg/ m^2, Vermicompost 500 g/ m^2, Perlite 500 g/ m^2 and microbial consortia 50 g/m^2] with a spacing of 12.5 x 10 cm. Long day conditions were given for 4-5 weeks after planting while the short-day conditions were achieved by closing the greenhouse growing area with the black polythene film from 18.00 h in the evening to 8.00 h in the morning. All other agronomic operations and plant protection measures were done as per the schedule. Five plants were randomly tagged in each of the plot (treatment and replication wise) and observed for growth and yield characters at critical stages of the crop growth. The data were statistically analyzed as per the method (Panse, and Sukhatme, 1985) [20]. The critical differences were worked out for 5 percent (0.05) probability and the mean differences were compared using LSD test.

Results and Discussion

The results revealed that the fertigation levels and foliar application of micronutrients had a significant influence on growth and flowering parameters.

Effect of levels of fertigation on growth parameters

Fig. 1 reveals that plant height was increased at 75 % RDF along with 0.2 % micronutrient mixture spray (T_6) at critical stages of the crop growth *viz.*, peak vegetative (60.57 cm), bud appearance (90.34 cm) and peak flowering stage (138.90 cm) which is on par with T_7 (57.1 cm, 85.64 cm and 135.80 cm). This was followed by T_2 and T_3 respectively. The increased plant height in T_6 might be due to frequent application of fertilizers at convenient intervals and at optimum dose, which increases the available nutrient status in the root zone thus increasing the uptake of nutrients and further influencing the growth of the plant. A sufficient supply of nutrients at frequent intervals might have increased the production of IAA which consequently would have shown stimulatory action, in terms of cell elongation and thus resulting in increased plant height. Pafli (1965) [19] suggested that nitrogen, being the chief constituent of chlorophyll, protein, and amino acids, is accumulated in the shoot through an increased supply of nitrogen to the plants at an appropriate time. Thus fertigation deserves one of the aspects that contribute to increased plant height while the lowest plant height was recorded in T_1 **(**30.40 cm, 45.87 cm, and 63.54 cm).

A crop should produce a sufficient number of leaves to harness the light energy and synthesize adequate photosynthates for biomass production. The leaves serve as the index of measurement of vegetative growth and in determining the yield potential. Data presented in the Table. 1 revealed that the maximum number of leaves was registered in T_6 (28.70, 36.54, and 38.44) followed by T_7, T_8, T_3 T_4, and these treatments were on par with T_6 while the minimum number was recorded in the T_1 (17.73, 24.08 and 25.99). An increase in fertilizer dose causes a reduction in their growth habits. Due to their involvement in protein synthesis, hormonal translocations and nitrogen assimilation, zinc, and boron contained in the micronutrient mixture might have complemented higher leaf production. Corroborative evidence could be obtained from the results of Tanvi *et al*. (2017) [30] and Ganesh *et al*. (2013c) [9] in tuberose.

Similar to the number of leaves, leaf area also showed a positive response to water-soluble fertilizer application (Table 2). Further, more leaf area was recorded in plants of T_6 in all the three stages (1003.17 cm^2, 1253.56 cm^2 and 1328.77 cm^2) followed by T_7 (950.86 cm^2, 1176.21 cm^2 and 1213.51 cm^2) which might be due to the combination of micronutrient mixture and humic acid which enhanced the cytokinin level which the cell division resulting in enhanced leaf area. Similar observations were reported by Sujatha *et al*. (2002) [29] in gerbera; Hardeep Kumar *et al*. (2003) [13] and Yadav *et al*. (2005) [32] in tuberose; Senthamizhselvi (2000) [23] in jasmine and Singh and Singh (2000) in gladiolus. The importance of zinc in the synthesis of tryptophan which is the precursor of auxin might have increased the auxin biosynthesis and iron's participation in the synthesis of chlorophyll in plants and thus resulting in greater photosynthetic activity, inturn increased photosynthates and growth that could be responsible for the increased leaf area and ultimately leaf area index. Ganesh and Kannan (2013b) [11] have opined that micronutrients improve growth characters due to enhance photosynthetic & metabolic activities related to cell division.

Table 1: Number of leaves of chrysanthemum var. Punch as influenced by different levels of fertigation

Treatments	Peak vegetative stage (cm)	Bud appearance stage (cm)	Peak flowering stage (cm)
T_1	17.93^g	24.08^g	25.99^e
T_2	24.96^c	31.54^c	33.78^b
T_3	24.01^{cd}	32.56^c	34.69^b
T_4	22.27^{ef}	27.84^e	30.04^d
T_5	21.33^f	26.34^f	31.60^c
T_6	28.70^a	36.54^a	38.44^a
T_7	26.68^b	34.10^b	35.09^b
T_8	23.10^{de}	29.32^d	29.55^d
T_9	18.33^g	24.65^g	28.64^d
S.Ed	0.521	0.669	0.725
CD (p=0.05)	1.104	1.419	1.538

Table 2: Total leaf area of chrysanthemum var. Punch as influenced by different levels of fertigation

Treatments	Peak vegetative stage (cm^2)	Bud appearance stage (cm^2)	Peak flowering stage (cm^2)
T_1	481.91^{g}	663.17^{g}	901.33^{e}
T_2	875.24^{c}	1072.63^{c}	1007.98^{c}
T_3	908.24^{c}	950.14^{d}	971.21^{cd}
T_4	731.30^{d}	800.24^{f}	848.87^{f}
T_5	529.62^{f}	880.56^{e}	928.07^{de}
T_6	1003.17^{a}	1253.56^{a}	1328.77^{a}
T_7	950.86^{b}	1176.21^{b}	1213.51^{b}
T_8	556.01^{f}	894.51^{e}	948.18^{de}
T_9	630.97^{e}	905.34^{de}	959.66^{cd}
S.Ed	17.239	21.973	23.066
CD (p=0.05)	36.545	46.580	48.899

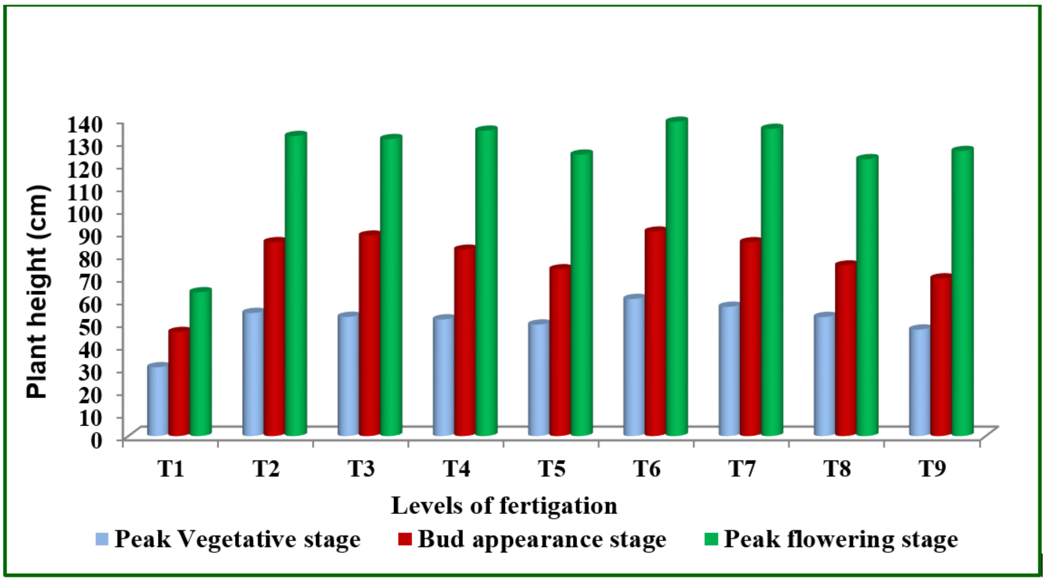

Fig 1: Plant height of chrysanthemum cv. Punch as influenced by levels of fertigation

Effect of levels of fertigation on flowering parameters

There was a significant influence of the fertigation levels on the flowering parameters. T_6 (75 % RDF at 12:3:12 g NPK/m^2 with a foliar spray of 0.2 % micronutrient mixture) recorded earlier flower bud appearance (50.26 days) and early to harvest (96.88 days) while T_1 took a maximum number of days for bud appearance (Table 3). Early flowering might be due to the combined effect of fertigation along with micronutrients creating a conducive source-sink relationship. Fertigation of N, P, K and foliar spray of micronutrients, being a constituent of proteins, amino acids, nucleic acid, various enzymes and coenzymes which are associated with the increased shoot length and leaf area resulted in more photosynthesis and thus increased the transformation of manufactured food material from source (leaf) to sink (flower bud). This conformed with the findings of Beniwal *et al*. (2005) [4] and Ganesh *et al*. (2014) [10] in Chrysanthemum. Similar results were also obtained by Marschner (2012) [16] and Sharma and Singh (2001) [25] in Gladiolus. Increased dose of fertilizer *viz.*, T_9, and T_5 delayed the initiation of flowering. The earlier studies by Antonio Eduardo *et al*. (2015) [2] and Khan *et al*. (2004) [15] have shown that increased doses of fertilizer delayed initiation of flowering in many ornamental plants.

Fertigation with 75 % RDF @ 12:3:12 g NPK/m^2 with 0.2% micronutrient mixture foliar spray (T_6) recorded highest flower stalk length (132.24 cm) followed by T_2 which recorded 130.44 cm (Table 3). Flower stalk length was increased with increased nutrient application/availability. The micronutrient combination in the fertigation dose might have improved the length of the flower stalk; such influence could be described due to enhanced photosynthetic support optimized by the presence of zinc and other micronutrients. This indicated the necessity to provide a combination of micronutrients to promote beneficial effects. Similar effects have also been documented by Patokar *et al*. (2017) [21] and Shah *et al*. (2016) [24] in marigold; and Prabhat Kumar and Arora (2002) [22] in gladiolus.

The flower parameters *viz.*, number of flowers per stalk, unopened flower bud circumference, and opened flower circumference increased by 100 % RDF with 0.2% micronutrient mixture (T_7) as a foliar spray (Table. 3). The results are in agreement with Bini Sundar (2014) [5] in *J. sambac*. The yield parameters like the number of flower buds per plant and marketable stem yield per unit area were significantly influenced by the irrigation methods and systems of fertilization. Shrikant and Jawaharlal (2014) also pointed out that fertigation of RDF at every irrigation (two-day intervals) up to 105 days resulted in a significantly higher yield of gerbera. The diameter of the flower is contributed by the number of petals, petal length, and width of flower. The results of the present study are also in line with the above finding, since the maximum availability of potassium through WSF (19:19: 19) and potassium nitrate for flower growth in the growing soil might be one of the reasons for the production of flowers with better size. This is well supported by Silberbush and Leith (2004) [27] in greenhouse roses, Ahmed *et al*. (2017) [1] in chrysanthemum. Furthermore, zinc acts as a catalyst in the oxidation and reduction reaction process and is of great importance in sugar metabolism which might have improved the flower characters. This is well supported by Sharma and Singh (2001) [25] in gerbera and Dhinesh *et al*. (2013) [6] in Carnation.

In the present study, fertigation levels significantly influenced the leaf to flower ratio. The plants of T_6 with 0.2 % micronutrient mixture spray recorded the highest leaf production and also recorded the highest flower yield (77.68 cut stems/m^2), thus revealing the strong correlation between the leaf to flower ratio. Since the soil solum is properly mixed with FYM and biofertilizers for extraction of nutrients along with enough moisture, the fertigation dose of 75 %, ultimately favours building up of turgor potential inside the plant system in a positive way. So this favourable change might have led to an increased number of flowers. Further, the application of multi-K might have had a direct positive role in producing more flowers and ultimately the flower yield. This might be due to reduced nutrient losses by leaching and efficient use of nutrients through fertigation, which has been well established by several workers (Ganesh *et al*., 2016; Bini Sundar, 2014) [8,5]. According to Durga Devi *et al*. (1997) [7] increase in flower yield might be attributed to the fact the application of iron and zinc relieved the plants from chlorosis and produced healthy green leaves which in turn resulted in higher assimilate synthesis and partitioning of the flower growth. Similar observations were earlier reported by Senthamizhselvi (2000) [23] in jasmine; Sharma and Singh (2001) [25] in gerbera and Mukesh Kumar *et al*. (2001) [18] in tuberose.

Effect of levels of fertigation on chlorophyll contents

Chlorophyll, the pigment responsible for harvesting solar energy and converting into chemical energy, exhibits a differential pattern in their accumulation in plants grown under different systems of irrigation and fertilization with distinct tomato cultivars. A slight fluctuation in chlorophyll is enough to trigger changes in the physiological processes of the plants particularly photosynthesis. Fertigation showed higher chlorophyll content in the leaves than control (Fig.2).

Analysis of leaf chlorophyll contents in different treatment combinations revealed that T_6 (75 % RDF @ 12:3:12 g NPK/m^2 with 0.2 % micronutrient mixtures spray) registered the highest total chlorophyll contents at all the three stages (1.76 mg g^{-1}, 2.02 mg g^{-1} and 2.09 mg g^{-1}). The phenomenon of increased chlorophyll content with increased nutrients as observed in the present study was also reported by several workers (Meenakshi and Vadivel, 2003; Virghine Tenzia, 2003) [17,31] and Balasubramaniam (2008) [3]. Hebbar *et al*. (2004) [14] also revealed that being a constituent of chlorophyll, an increased supply of nitrogen accelerate high synthesis of chlorophyll without altering the composition of chlorophyll *a* and *b*. Nitrogen along with phosphorous and potassium is the most recognized basic element required for most metabolic activities of the plants resulting in the synthesis of chlorophyll cytochrome which are essential for photosynthesis and respiration process of the tomato plant.

Table 3: Flowering parameters of chrysanthemum var. Punch as influenced by different levels of fertigation

Treatments	Day taken for first flower bud appearance	Days to first harvest	Flower stalk length (cm)	Number of flowers per stalk	Unopened flower bud circumference (cm)	opened flower circumference (cm)	Marketable stem yield /m^2
T_1	53.5e	108.55^{i}	58.29^{f}	8.74^{g}	2.94^{i}	4.15^{f}	62.09^{e}
T_2	48.86bc	99.89^{d}	130.44^{ab}	12.27^{c}	3.15^{d}	7.53^{b}	73.69^{bc}
T_3	49.76cd	98.79^{c}	120.44^{d}	11.76^{cd}	3.27^{c}	7.84^{b}	71.38^{cd}
T_4	51.92de	101.65^{e}	126.54^{c}	9.74^{ef}	3.10^{e}	6.76^{c}	73.94^{bc}
T_5	50.15cd	104.98^{g}	115.3^{e}	11.25^{d}	2.98^{h}	5.53^{d}	70.11^{d}
T_6	45.27a	95.74^{a}	132.24^{a}	14.42^{b}	3.30^{b}	8.48^{a}	77.68^{a}
T_7	47.08ab	96.88^{b}	129.73^{b}	15.55^{a}	3.56^{a}	8.54^{a}	75.36^{ab}
T_8	50.26cd	106.32^{h}	114.6^{e}	9.53^{f}	3.08^{f}	4.53^{e}	72.14^{bcd}
T_9	52.74e	103.26^{f}	119.95^{d}	10.26^{e}	3.04^{g}	4.74^{e}	69.35^{d}
S.Ed	2.380	0.156	1.160	0.267	0.006	0.151	1.611
CD (p=0.05)	0.212	0.331	2.460	0.566	0.013	0.321	3.416

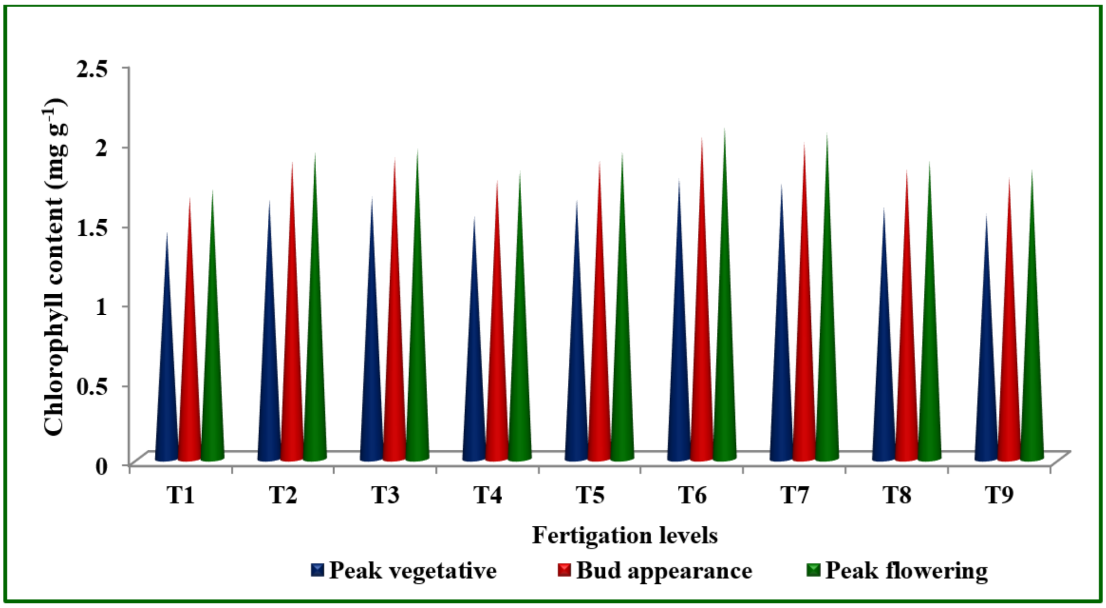

Fig 2: Total chlorophyll content of chrysanthemum as influenced by levels of fertigation

Conclusion

Fertigation with 75 % recommended dose of water-soluble fertilizers (12:3:12 g/ NPK/m^2) through drip irrigation and 0.2% micronutrient mixture as foliar spray proved its superiority by registering improved vegetative (plant height, number of leaves and total leaf area, etc.) and flowering parameters *viz.*, days for first flower bud emergence, days to harvest, flower stalk length, number of flower per stalk, flower stalk length, flower bud circumference and marketable stem yield per square meter. Therefore, 75 % of RDF through fertigation in chrysanthemum is recommended.

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