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# Effect of irrigation schedule and fertigation of water soluble and nano fertilizer on growth and flowering of gerbera in greenhouse

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## ABSTRACT

*The experiment was carried out during the years 2023–24 and 2024–25 at the Greenhouse Complex, Department of Floriculture and Landscape Architecture, ASPEE College of Horticulture, Navsari Agricultural University, Navsari with the objective to evaluate the effects of different drip irrigation levels and fertigation levels using water-soluble and nano fertilizers on the growth and flowering of Gerbera jamesonii cv. Terra Kalina is grown under protected cultivation. The experiment was laid out in a completely randomized design using a factorial concept with main factor comprising of three drip irrigation levels ($I_1$: 0.6 PEF, $I_2$: 0.8 PEF and $I_3$: 1.0 PEF) and sub factor of three fertigation levels ($F_1$- 19:19:19 NPK 0.12 gm/plant + 00:00:50 NPK 0.12 gm/plant (water soluble fertilizer), $F_2$- 19:19:19 NPK 0.03 gm/plant + 00:00:50 NPK 0.03 gm/plant (Nano fertilizer) and $F_3$- 17:44:00 NPK 0.03 gm/plant + 13:00:45 NPK 0.03 gm/plant (Nano fertilizer)), involving different combinations of water-soluble and nano NPK fertilizers. Treatments were applied on alternate days throughout the crop cycle of two year. The pooled analysis over two years revealed that both individual and interaction effects of irrigation and fertigation treatments significantly influenced on vegetative growth and flowering as well as yield. Among all treatment combinations, the plants treated with $I_1F_2$ - 0.6 PEF drip irrigation level and fertigation level (19:19:19 NPK 0.03 g/plant + 00:00:50 NPK 0.03 g/plant (Nano fertilizer) recorded the highest plant height (36.10 cm), maximum number of leaves (36.29), maximum plant spread (37.29 cm) and maximum leaf area (36.96 cm$^2$) with highest flower yield (48.05 flowers/plant/year), maximum flower diameter (9.19 cm), longest stem length (63.10 cm) as well as extended vase life (10.89 days) of gerbera. The present study indicate that the combination of $I_1F_2$ proved to be the most efficient in terms of maximizing growth and flower yield. There is need to standardize the irrigation level and fertilizer dose to increase the water use efficiency and fertilizer use efficiency. This research work accomodates sustainable and water-efficient strategy for gerbera cultivation under greenhouse conditions, particularly in regions facing water scarcity.*

***Keywords:*** *PEF, Nano fertilizer, Evapotranspiration, and Fertigation.*

## INTRODUCTION

Gerbera (*Gerbera jamesonii*) is a stemless and tender perennial herb that belongs to the Asteraceae family and Carl Linnaeus named it by showing honour to German scientist Traugott Gerber (1710-1743). It grows naturally in South Africa, Africa, Madagascar, and tropical Asia.Gerbera is one among the top ten cut flowers of the world flower trade, which rank fifth in the International flower trade. Gerbera is very popular and widely used as a decorative garden plant in landscape or as a cut flower in various floral arrangements. Due to the increasing demand of this cut flower which generally grows under protected structures, there arises a need for better adoption of various cultural factors to produce flowers of export quality [5]. Nutrition plays a major role in getting higher yield. Gerbera being a herbaceous perennial plant, requires plenty of organic matter and adequate nutrients, especially phosphorus and potassium for profuse flowering.

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Fertigation is one such technique of applying nutrients through micro irrigation systems directly at the site of active root zone. Though a new concept in India, it has potential for more accurate and timely crop nutrition leading to increased yield, enhanced quality and early crop maturity. Adequate supply of water and nutrients results in higher water and nutrient use efficiency, better production control and avoidance of stress situations [42]. Gerbera is one of the popular commercial cut flower in the world, however, research based on its irrigation requirement as well as fertigation comparing nano and conventional water soluble fertilizers is inadequate. Thus, this research will be helpful for to determine the optimum amount of water and nutrients for the gerbera crop especially in the area where water scarcity is prominent.

## MATERIALS AND METHODS

### Geographical features of study area

The experiment was carried out in naturally ventilated polyhouse at greenhouse complex, Department of Floriculture and Landscape Architecture, ASPEE College of Horticulture, Navsari Agricultural University, Navsari which is situated at 20° - 57´ North latitude and 72°-54' East longitude at an altitude of 11.98 m above mean sea level and three kilometres away in the west from Navsari and 13 kilometres away in the east from

 

Arabian seashore, the historical place 'Dandi'.

**Experimental details**

Experimental treatments included two factors, *viz.,* the main factor-1 having 3 different drip irrigation levels ($I_1$ - 0.6 PEF, $I_2$ - 0.8 PEF and $I_3$ - 1.0 PEF) and the sub factor-2 having the combination of different water soluble and nano fertilizer ($F_1$- 19:19:19 NPK 0.12 g/plant + 00:00:50 NPK 0.12 g/plant (water soluble fertilizer), $F_2$- 19:19:19 NPK 0.03 g/plant + 00:00:50 NPK 0.03 g/plant (Nano fertilizer) and $F_3$- 17:44:00 NPK 0.03 g/plant + 13:00:45 NPK 0.03 g/plant (Nano fertilizer)).

**Determination of crop water and irrigation requirement**

The evaporation in the greenhouse was estimated through Class - A pan evaporimeter every day in the morning at 8.00 a.m. The reference evapotranspiration ($ET_0$) was calculated by multiplying the $E_{pan}$ with the pan coefficient ($K_{pan}$). The crop evapotranspiration (ETc) was estimated by using the value of reference evapotranspiration ($ET_0$) combined with crop factor (Kc) of gerbera at different growth stages and the irrigation water requirement was calculated using the formula described by [3] according to the treatment eg. $I_1$- 0.6 PEF, $I_2$- 0.6 PEF and $I_3$- 0.6 PEF.

$ET_0(mm) = E_{pan}(mm) \times K_{pan}$

$ETc = ET_0(mm) \times Kc$

Irrigation Depth (Ir) (mm) = $ETc \times P_{EF}$

$$\text{Irrigation Water Quantity} = \text{Lateral spacing} \times \text{Dripper spacing} \times \text{Irrigation depth (litre Plant}^{-1})$$

$$\text{Irrigation Time (I)} = \frac{\text{Irrigation Water Quantity (litre Plant}^{-1})}{\text{Dripper capacity (litre hr}^{-1})}$$

*Table 1: Crop coefficient factor for Gerbera at different growth stages*

| Sr. No. | Days after transplant | Phases | Crop Factor (Kc) | Evapotranspiration $ET_0$ |
|---|---|---|---|---|
| 1. | 0-29 | Vegetative I | 0.72 | 2.91 |
| 2. | 29-58 | Vegetative II | 0.81 | 2.92 |
| 3. | 58-87 | Flowering I | 0.85 | 3.18 |
| 4. | 87-116 | Full flowering I | 0.89 | 3.22 |
| 5. | 116-145 | Full flowering II | 1.33 | 2.58 |
| 6. | 145-174 | End of Flowering I | 1.06 | 1.81 |

*[Source: 33]*

**Application of treatments**

Prepared fertilizer combinations *i.e.*, $F_1$, $F_2$ and $F_3$ were given to the plants by fertigation via drip irrigation at alternate day according to the calculation of irrigation water quantity for the calculated irrigation time required *i.e.*, $I_1$, $I_2$ and $I_3$ for each treatment combination.

**Design**

CRD with factorial concept with the total 9 treatment combinations and 4 replication

**Preparation of beds for experimental trial**

Thirty days prior to planting, soil was sterilized with 5 % Formalin (12 to 15 lit of Formaldehyde per 100 lit water). Soil was drenched with Formalin solution and completely covered with black polythene sheet and left as such for 72 hours. Polythene sheet was removed after a certain period and soil was drenched with a copious amount of water and raked continuously at certain intervals to make it free from the traces of formalin. Then the soil was levelled and raised beds of 45 cm height and 60 cm width with 50 cm pathway were prepared. Then Tissue cultured plants of Gerbera var. Tara Kalina were planted at a spacing of 30 cm x 30 cm x 50 cm with net plot size 1.50 m x 1.10 m and gross plot size 2.10 m x 1.10 m.

**Application of Fertigation and Cultural practices**

In each bed treatment (bed) there were four replications. The replications kept between main plots to eliminate influence of lateral water movement. Each replication contain 14 plants in gross plot and 12 plant in net plot in a zigzag manner with spacing in of 30 cm. All plots in the experimental field were irrigated with dripper flow rate of 4 l $h^{-1}$. Water for each plots passed through laterals placed in gerbera beds. A mini-valve was installed in the lateral to control water flow of the dripper line. The uniformity of emitter water application was checked by recording the time needed for the discharge to fill a vessel of known volume. The average discharge of the emitters was found to be 3.8 l $h^{-1}$ and the uniformity coefficient was more than 90% for all the blocks. The standard cultural practices were adopted for the cultivation of Gerbera crop. Racking was done regularly to prevent soil compaction and to improve soil aeration also. The dry and diseased leaves were removed along with weeding periodically to keep the greenhouse clean.

**Observations recorded**

Growth parameters *viz*., Plant height (cm), Number of sucker, Number of leaves, plant spread (cm) and leaf area ($cm^2$) and flowering parameters viz., Flower diameter (cm), Stem length (cm) and Vase life (days) were recorded at $P_1$, $P_2$, $P_3$ and $P_4$ period at $6^{th}$ month interval for two year and data of Yield (No. of flowers/plant/year) noted for every months and counted for year yield.

**Statistical analysis**

The data on various observations recorded during the course of investigation were statistically analyzed using Completely Randomized design with factorial concept along with pooled analysis as suggested by [31]. The appropriate standard error of mean (S.Em.±) calculated in each treatment, and the critical difference (C.D.) were calculated at 5 per cent level of probability was worked out to compare the treatment means where the treatment effects were significant. Data have been depicted by suitable figures with the appropriate tables.

## RESULTS AND DISCUSSION

Results reveals that the different drip irrigation levels and water soluble and nano fertilizers significantly affects on growth and flowering in gerbera var. Tera Kalina, individually as well as the interaction effects of both the factors were also found significant.

**Plant Height**

It is exhibited from the data presented in Table 2 that among all the drip irrigation levels, significantly maximum plant height (34.59 cm) was observed in plants treated with 0.6 PEF drip irrigation level ($I_1$). Among all different fertigation levels, the significantly maximum plant height (33.57 cm) was recorded in plants treated with fertigation level $F_2$. It is noticeable from the data that among all treatment combinations of drip irrigation level and fertigation levels, the significantly maximum plant height (36.10 cm) was observed in the treatment combination of $I_1F_2$.

 

*Table 2: Effect of drip irrigation and fertigation on plant height (cm) in gerbera var. Terra Kalina*

| | Plant height (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| Treatments | $F_1$ | | $F_2$ | | $F_3$ | | Mean (I) |
| $I_1$ | 32.93 | | 36.10 | | 34.75 | | 34.59 |
| $I_2$ | 30.98 | | 32.42 | | 31.30 | | 31.57 |
| $I_3$ | 26.68 | | 32.19 | | 30.49 | | 29.78 |
| Mean (F) | 30.20 | | 33.57 | | 32.18 | | |
| | P | I | P x I | F | P x F | I x F | P x I x F |
| SEm (±) | 0.14 | 0.44 | 0.25 | 0.23 | 0.25 | 0.22 | 0.43 |
| CD @ 5% | 0.40 | 1.54 | 0.69 | 0.79 | 0.69 | 0.61 | NS |
| CV % | 2.68 | | | | | | |

## Number of Sucker

It is recorded from the data presented in Table 3 that among all the drip irrigation levels, significantly maximum number of sucker (3.28) was observed in plants treated with 0.6 PEF drip irrigation level ($I_1$). Among all different fertigation levels, the significantly maximum number of sucker (3.20) was showed in plants treated with fertigation level $F_2$ (19: 19: 19 NPK 0.03 g/plant + 00:00:50 NPK 0.03 g/plant (Nano fertilizer)). It is visible from the data that among all treatment combinations of drip irrigation level and fertigation levels, the significantly maximum number of sucker (3.58) was observed in treatment combination of $I_1F_2$.

*Table 3: Effect of drip irrigation and fertigation on number of sucker in gerbera var. Terra Kalina*

| | Number of sucker | | | | | | |
|---|---|---|---|---|---|---|---|
| Treatments | $F_1$ | | $F_2$ | | $F_3$ | | Mean (I) |
| $I_1$ | 2.91 | | 3.58 | | 3.34 | | 3.28 |
| $I_2$ | 2.98 | | 3.08 | | 3.15 | | 3.07 |
| $I_3$ | 2.38 | | 2.96 | | 2.41 | | 2.58 |
| Mean (F) | 2.75 | | 3.20 | | 2.97 | | |
| | P | I | P x I | F | P x F | I x F | P x I x F |
| SEm (±) | 0.02 | 0.02 | 0.04 | 0.02 | 0.04 | 0.07 | 0.07 |
| CD @ 5% | 0.06 | 0.06 | NS | 0.06 | NS | 0.23 | 0.19 |
| CV % | 4.48 | | | | | | |

## Number of Leaves

It is recorded from the data presented in Table 4 that among all the drip irrigation levels, significantly maximum number of leaves (34.24) was observed in plants treated with 0.6 PEF drip irrigation level ($I_1$). Among all different fertigation levels, the significantly maximum number of leaves (33.66) was showed in plants treated with fertigation level $F_2$. Whereas, interaction effect was found nonsignificant.

*Table 4: Effect of drip irrigation and fertigation on number of leaves in gerbera var. Terra Kalina*

| | Number of leaves | | | | | | |
|---|---|---|---|---|---|---|---|
| Treatments | $F_1$ | | $F_2$ | | $F_3$ | | Mean (I) |
| $I_1$ | 31.68 | | 36.29 | | 34.75 | | 34.24 |
| $I_2$ | 28.25 | | 32.41 | | 29.38 | | 30.01 |
| $I_3$ | 24.74 | | 32.28 | | 28.10 | | 28.37 |
| Mean (F) | 28.22 | | 33.66 | | 30.74 | | |
| | P | I | P x I | F | P x F | I x F | P x I x F |
| SEm (±) | 0.36 | 0.66 | 0.62 | 0.73 | 0.62 | 1.15 | 1.07 |
| CD @ 5% | 0.98 | 2.28 | 1.79 | 2.53 | 1.79 | NS | 3.09 |
| CV % | 6.91 | | | | | | |

## Plant Spread

It is noted from the data presented in Table 5 that among all the drip irrigation levels, significantly maximum plant spread (35.87 cm) was observed in plants treated with 0.6 PEF drip irrigation level ($I_1$). Among all different fertigation levels, the significantly maximum plant spread (32.99 cm) was showed in plants treated with fertigation level $F_2$.

It is visible from the data that among all treatment combinations of drip irrigation level and fertigation levels, the significantly maximum plant spread (37.29 cm) was observed in treatment combination of $I_1F_2$.

*Table 5: Effect of drip irrigation and fertigation on plant spread (cm) in gerbera var. Terra Kalina*

| | Plant spread (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| Treatments | $F_1$ | | $F_2$ | | $F_3$ | | Mean (I) |
| $I_1$ | 34.73 | | 37.29 | | 35.59 | | 35.87 |
| $I_2$ | 26.31 | | 34.23 | | 27.85 | | 29.47 |
| $I_3$ | 25.02 | | 27.44 | | 27.39 | | 26.62 |
| Mean (F) | 28.69 | | 32.99 | | 30.28 | | |
| | P | I | P x I | F | P x F | I x F | P x I x F |
| SEm (±) | 0.19 | 0.16 | 0.34 | 0.17 | 0.34 | 0.28 | 0.58 |
| CD @ 5% | NS | 0.46 | NS | 0.46 | NS | 0.78 | NS |
| CV % | 3.82 | | | | | | |

## Leaf area

It is exhibited from the data presented in Table 6 that among all the drip irrigation levels, significantly maximum leaf area (35.57 $cm^2$) was observed in plants treated with 0.6 PEF drip irrigation level ($I_1$). Among all different fertigation levels, the significantly maximum leaf area (34.50 $cm^2$) was showed in plants treated with fertigation level $F_2$. It is visible from the data that among all treatment combinations of drip irrigation level and fertigation levels, the significantly maximum leaf area (36.96 $cm^2$) was observed in treatment combination of $I_1F_2$.

*Table 6: Effect of drip irrigation and fertigation on leaf area (cm2) in gerbera var. Terra Kalina*

| | Leaf area ($cm^2$) | | | | | | |
|---|---|---|---|---|---|---|---|
| Treatments | $F_1$ | | $F_2$ | | $F_3$ | | Mean (I) |
| $I_1$ | 34.79 | | 36.96 | | 34.96 | | 35.57 |
| $I_2$ | 29.43 | | 35.11 | | 29.80 | | 31.45 |
| $I_3$ | 25.91 | | 31.43 | | 30.81 | | 29.39 |
| Mean (F) | 30.04 | | 34.50 | | 31.86 | | |
| | P | I | P x I | F | P x F | I x F | P x I x F |
| SEm (±) | 0.21 | 0.18 | 0.36 | 0.18 | 0.36 | 0.30 | 0.62 |
| CD @ 5% | NS | 0.49 | NS | 0.49 | NS | 0.83 | NS |
| CV % | 3.87 | | | | | | |

Fertilizers play a vital role in enhancing plant growth by supplying essential nutrients that support metabolic pathways, increase biomass and flower production, and maintain physiological processes, especially when applied in scientifically recommended doses [10 and 27]. Most plants require nitrogen (N), phosphorus (P), and potassium (K), as these macronutrients play a vital role in supporting their growth and development by regulating physiological processes, enzyme activity, and structural composition [16, 21 and 43]. Moreover, Fertilizers are available in different forms as water soluble, non water soluble and recently nano fertilizers available in the market with particle size (1–100 nm). These nano sized formulations are specifically engineered to promote controlled, sustained release and localized uptake of macro- and micronutrients achieving superior synchronization with crop physiological demand compared to traditional bulk fertilizers [26 and 24]. Conventional fertilizers often lose nutrients through leaching, volatilization, or fixation, with nitrogen and phosphorus use efficiencies as low as 30–40% and 15–20%, respectively. Beyond nutrient delivery, nano-fertilizers also positively influence root system architecture, stimulate microbial populations in the rhizosphere, and enhance plant resilience under abiotic stress, supporting improved nutrient uptake, growth, and stress adaptation [41 and 26].

In the present experiment, highly significant effect was observed with the application of fertilizer level $F_2$ over $F_1$ and $F_3$.

$F_2$ comprising of (19:19:19 NPK 0.03 g/plantand00:00:50 NPK0.03 g/plant) in nano form may have contributed in better plant growth *viz*. plant height, number of suckers, number of leaves, plant spread and leaf area owing to higher efficiency of nutrient uptake and nutrient mobility within plant systems due to its small particle size [34 and 19]. Moreover, NPK 19:19:19 in nano form supplies balance nutrition, supporting chlorophyll formation, protein synthesis, root development, and enzymatic regulation in plants [34 and 19]. Meanwhile, nano 00:00:50 is a potassium-rich fertilizer that enhances cell elongation, stem strength, water regulation, and overall stress resistance. Further, nano fertilizers provided a controlled and sustained release of nutrients that aligns with the plant's growth demands, leading to increased plant height, leaf number, stem thickness, and biomass accumulation as also elaborated by [11 and 9]. Further beneficial effects of nano fertilizers have been reported in floricultural crops like Kalenchoe [19], *Codiaeum variegatum* L. cv. Gold Dust [1] and Gerbera [35].

Proper irrigation scheduling is vital for ensuring optimal plant growth and high-quality flowering. When soil moisture falls below the optimum threshold due to deficit irrigation, plants experience water stress. Limited water availability in the root zone, reduces turgor pressure which is interrupts with cell expansion and leaf elongation. Additionally, water deficit conditions enhance the production of reactive oxygen species (ROS), which cause oxidative damage to lipids, proteins, and nucleic acids ultimately disrupting membrane integrity and enzymatic function [39 and 30]. Concurrently, the uptake of essential nutrients, particularly nitrogen and potassium, becomes constrained due to reduced mass flow and root activity, leading to declines in leaf expansion and dry matter accumulation. Thus, lack of water disrupts multiple physiological processes *viz*. reduced photosynthetic efficiency, stunted growth, and smaller leaf area [13 and 39]. In flower crops, this results in fewer and smaller inflorescences, delayed blooming, and overall reduced aesthetic quality [12 and 30]. At optimum irrigation, theroot zone remains adequately aerated, ensuring proper oxygen diffusion to roots while facilitating efficient nutrient solubilization and uptake [20]. This allows for uninterrupted photosynthesis, enzyme activity, and cell expansion, which are essential for canopy growth, chlorophyll synthesis, and flower bud differentiation [46]. Moreover, sufficient soil moisture sustains turgor pressure, which is necessary for leaf expansion and stem elongation both crucial for increasing biomass and flower production. In contrast, over-irrigation or waterlogging saturates the soil, displacing air from pore spaces and creating anaerobic conditions that drastically reduce root oxygen availability and impair respiration [30] This oxygen deficiency hampers root function which leads to reduced nutrient uptake while stomatal closure, accelerated chlorophyll degradation, and leaf senescence result in diminished photosynthesis and delayed or poor-quality flowering [44 and 30].

In the present experiments, 0.6 PEF drip irrigation level found to be significant on signficantly increased growth parameter *viz*. plant height, number of leaves, number of suckers, plant spread as well as leaf area. This implies that 0.6 PEF could be optimum for gerbera which increased plant growth by maintaining consistent soil moisture levels, which may be supported efficient nutrient uptake with enhanced photosynthesis and reduced physiological stress, ultimately leading to improved biomass accumulation as also observed by [17].

In gerbera, prolonged soil saturation significantly decreased root biomass and flower stem elongation due to reduced mitochondrial activity in root cells [30 and 29]. Similarly, in carnation, excessive irrigation led to leaf yellowing and bud abortion, linked to nutrient leaching and oxygen deprivation [44 and 29]. In rose, waterlogged conditions caused a 30–40% drop in chlorophyll content and suppressed floral bud development due to impaired gas exchange and oxidative damage [2]. Beneficial effects of 0.6 PEF on growth parameters reported in Gladiolus [45]. Further, beneficial effects of 1.0 PEF on growth parameters reported in Rose [14] and Tuberose [32].

## Yield

It is observed from the data presented in Table 7 that among all the drip irrigation levels, significantly maximum yield (45.00 flowers/plant/year) was noted in plants treated with 0.6 PEF drip irrigation level($I_1$) which was statistically at par with treatment $I_2$ (43.58 flowers/plant/year). Among all different fertigation levels, the significantly maximum yield (45.21 flowers/plant/year) was recorded in plants treated with fertigation level $F_2$. It is visible from the data that among all treatment combinations of drip irrigation level and fertigation levels, the significantly maximum yield (48.05 flowers/plant/year) was observed in treatment combination of $I_1F_2$ which was statistically at par with treatment combination $I_1F_3$ (46.55 flowers/plant/year).

*Table 7: Effect of drip irrigation and fertigation on yield (No. of flower/plant/year) in gerbera var. Terra Kalina*

| | Yield (flowers/plant/year) | | | | | | |
|---|---|---|---|---|---|---|---|
| Treatments | $F_1$ | | $F_2$ | | $F_3$ | | Mean (I) |
| $I_1$ | 40.40 | | 48.05 | | 46.55 | | 45.00 |
| $I_2$ | 43.28 | | 43.65 | | 43.83 | | 43.58 |
| $I_3$ | 36.55 | | 43.93 | | 36.85 | | 39.11 |
| Mean (F) | 40.08 | | 45.21 | | 42.41 | | |
| | Year | I | Y x I | F | Y x F | I x F | Y x I x F |
| SEm (±) | 0.47 | 0.57 | 0.81 | 0.56 | 0.81 | 0.96 | 1.41 |
| CD @ 5% | 1.32 | 1.60 | NS | 1.60 | NS | 2.72 | NS |
| CV % | 6.61 | | | | | | |

## Flower Diameter

It is exhibited from the data presented in Table 8 that among all the drip irrigation levels, significantly maximum flower diameter (8.82 cm) was observed in plants treated with 0.6 PEF drip irrigation level ($I_1$). Among all different fertigation levels, the significantly maximum flower diameter (8.74 cm) was recorded in plants treated with fertigation level $F_2$. It is visible from the data that among all treatment combinations of drip irrigation levels and fertigation levels, the significantly maximum flower diameter (9.19 cm) was found in the treatment combination of $I_1F_2$.

*Table 8: Effect of drip irrigation and fertigation on flower diameter (cm) in gerbera var. Terra Kalina*

| | Flower diameter (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| Treatments | $F_1$ | | $F_2$ | | $F_3$ | | Mean (I) |
| $I_1$ | 8.39 | | 9.19 | | 8.86 | | 8.82 |
| $I_2$ | 8.12 | | 8.47 | | 8.46 | | 8.35 |
| $I_3$ | 7.31 | | 8.55 | | 8.27 | | 8.05 |
| Mean (F) | 7.94 | | 8.74 | | 8.53 | | |
| | P | I | P x I | F | P x F | I x F | P x I x F |
| SEm (±) | 0.06 | 0.05 | 0.10 | 0.05 | 0.10 | 0.09 | 0.18 |
| CD @ 5% | NS | 0.14 | NS | 0.14 | NS | 0.24 | NS |
| CV % | 4.24 | | | | | | |

 

## Stem Length

It is revealed from the data presented in Table 9 that among all the drip irrigation levels, significantly maximum stem length (60.42 cm) was observed in plants treated with 0.6 PEF drip irrigation level($I_1$). Among all different fertigation levels, the significantly maximum stem length (60.29 cm) was showed in plants treated with fertigation level $F_2$. It is noticeable from the data that among all treatment combinations of drip irrigation level and fertigation levels, the significantly maximum stem length (63.10 cm) was observed in treatment combination of $I_1F_2$..

*Table 9: Effect of drip irrigation and fertigation on stem length (cm) in gerbera var. Terra Kalina*

| Treatments | Stem length (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | $F_1$ | | $F_2$ | | $F_3$ | | Mean (I) |
| $I_1$ | 56.47 | | 63.10 | | 61.71 | | 60.42 |
| $I_2$ | 49.06 | | 59.47 | | 57.98 | | 55.51 |
| $I_3$ | 46.45 | | 58.31 | | 46.66 | | 50.47 |
| Mean (F) | 50.66 | | 60.29 | | 55.45 | | |
| | P | I | P x I | F | P x F | I x F | P x I x F |
| SEm (±) | 0.30 | 0.26 | 0.53 | 0.26 | 0.53 | 0.43 | 0.91 |
| CD @ 5% | NS | 0.72 | NS | 0.72 | NS | 1.21 | NS |
| CV % | 3.29 | | | | | | |

## Vase life

It is recorded from the data presented in Table 10 that among all the drip irrigation levels, significantly maximum vase life (10.83 days) was observed in plants treated with 0.6 PEF drip irrigation level($I_1$). Among all different fertigation levels, the significantly maximum vase life (10.38 days) was recorded in plants treated with fertigation level $F_2$ which was statistically at par with $F_3$ (10.33 days). It is perceptible from the data that among all treatment combinations of drip irrigation level and fertigation levels, the significantly maximum vase life (10.89 days) was observed in treatment combination of $I_1F_2$, which was statistically at par with treatment combination $I_1F_3$ and $I_1F_1$ (10.83 days and 10.78 days, respectively).

*Table 10: Effect of drip irrigation and fertigation on vase life (days) in gerbera var. Terra Kalina*

| Treatments | Vase life (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | $F_1$ | | $F_2$ | | $F_3$ | | Mean (I) |
| $I_1$ | 10.78 | | 10.89 | | 10.83 | | 10.83 |
| $I_2$ | 10.09 | | 10.21 | | 10.18 | | 10.16 |
| $I_3$ | 8.60 | | 10.05 | | 9.98 | | 9.54 |
| Mean (F) | 9.82 | | 10.38 | | 10.33 | | |
| | P | I | P x I | F | P x F | I x F | P x I x F |
| SEm (±) | 0.06 | 0.05 | 0.10 | 0.05 | 0.10 | 0.08 | 0.17 |
| CD @ 5% | NS | 0.13 | NS | 0.13 | NS | 0.22 | NS |
| CV % | 3.29 | | | | | | |

Employing nano fertilizers in a responsible and optimized manner has the potential to contribute to more sustainable agricultural practices by reducing fertilizer inputs and minimizing environmental impacts. This approach can enhance crop yields while potentially lowering production costs [23 and 28]. Application of NPK fertilizers in nano form is known to improve the growth, yield, and quality of ornamental plants by enhancing nutrient uptake, promoting vegetative vigor, and improving flowering characteristics [38 and 25]. In addition, balanced nutrition, particularly in the form of NPK, plays a key role in regulating physiological and biochemical processes that determine plant aesthetics and market value [38]. Therefore, it is crucial to optimize fertilizer application rates to maximize the yield and quality of ornamental plants while minimizing environmental impact.

The application of $F_2$ (NPK 19:19:19 and NPK 00:00:50) in nano form significantly enhanced flower yield, flower diameter, stem length and vase life in gerbera. This might be due to specific attributes of nano fertilizers e.g., enhanced nutrient uptake efficiency, slow release of nutrion and mobility of nano particles as earlier discussion in growth parameters [18]. Moreover, Potassium (K) enhances flower quality, strengthens stems, and supports enzymatic and osmotic regulation in plants with application of 00:00:50 in nano form [43, 29 and 15]. Further, growth and flowering characters in plants are closely interconnected, as robust vegetative growth establishes the physiological and structural foundation necessary for successful floral initiation and development [40 and 37]. Strong vegetative traits such as increased leaf area, stem thickness, and root biomass enhance photosynthetic capacity, nutrient uptake, and hormone production, all of which are critical for triggering and sustaining flowering processes [36 and 37]. Thus, enhanced plant growth contributed to increased flower yield, flower diameter, stem length and vase life in gerbera. Positive impact of nano fertilizers in flowering parameters has been recorded in marigold [6] and gladiolus [7].

The effect of 0.6 PEF drip irrigation level was found significant on yield, flowering and quality parameters *viz*. flower yield, flower diameter, stem length, and vase life. Applying irrigation at 0.6 PEF (60% of crop evapotranspiration) increased flowering and yield in inducing mild water stress, which enhanced water use efficiency and promoted reproductive development. Optimal PEF regulates deficit irrigation and is known to improve flower quality, reduce excessive vegetative growth, and optimize resource use in different crops [20 and 8]. Beneficial effects of optimal PEF has been reported in improved yield and flower quality in marigold (*Tagetes erecta*) [46 and 22] and carnation [4].

## CONCLUSION

On the basis of the results stated above, it is concluded that drip irrigation level $I_1$ (0.6 PEF) and fertigation level $F_2$ (19:19:19 NPK 0.03 g/plant + 00:00:50 NPK 0.03 g/plant (Nano fertilizer)) registered for maximum growth, flowering quality and yield parameters in gerbera plant individually as well as in treatment combination as $I_1F_2$. This proved to be economical for the production of gerbera under optimum water condition with balanced nano fertilizer. In future more research work can be done regarding irrigation level and nano fertilizers.

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