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Effect of Combined Application of Nano Urea and Custom Blended Thermochemical Organic Fertilizer for Growth and Yield of Gerbera (*Gerbera jamesonii* Bolus)

Kalyani T.G [a*], Reshmi C.R [a], Rafeekher M [a], Priya Kumari I [a] and Naveen Leno [b]

[a] Department of Floriculture and Landscaping, College of Agriculture, Vellayani, Thiruvananthapuram – 695522, India.
[b] Department of Soil Science, College of Agriculture, Vellayani, Thiruvananthapuram – 695522, India.

Authors' contributions

This work was carried out in collaboration among all authors. Authors RCR and RM conceptualized and designed the research work. Author KTG executed the field/lab experiments and collected the data. Authors KTG, RCR, PKI and NL analyzed the data and interpreted the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

A study was carried out to evaluate the impact of combined application of nano urea liquid fertilizer and custom blended thermochemical organic fertilizer on the growth and yield of the gerbera (*Gerbera jamesonii* Bolus) variety "Natasha" under naturally ventilated polyhouse conditions. The experiment was conducted in 2021-2022 inside a naturally ventilated polyhouse in the Department

**Corresponding author: E-mail: geethakalyani123@gmail.com;*

of Floriculture and Landscaping, College of Agriculture, Vellayani using 3-month-old tissue culture plantlets of gerbera variety 'Natasha'. The experiment was laid out in CRD with 10 treatments and 15 replications. The results of the study revealed fortnightly foliar application of nano urea and soil application of thermochemical organic fertilizer custom blended with rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O per plant significantly improved the parameters like plant spread, number of leaves per plant, leaf length, leaf area and number of suckers per plant. Flower diameter, number of flowers produced per month, length of the flower stalk and bloom life were greatly improved by fortnightly soil application of thermochemical organic fertilizer custom blended with urea, rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O per plant.

Keywords: Gerbera; nano urea; organic fertilizer; thermochemical; custom blended.

1. INTRODUCTION

Gerbera, a member of Asteraceae family, is renowned for its gorgeous colour, lengthy vase life and suitability of flowers for long distance transportation. Application of balanced nutrients plays a prime role in quality gerbera production in protected structures. For proper growth and production, it requires plenty of organic matter and ample nutrients. Gerbera requires 40 g N, 20 g P_2O_5, and 90 g K_2O per m^2 per year for the best results [1]. The availability of P and K levels in growth media correlates positively with flowering indices, promoting plant growth in gerbera [2].

The leaf area of gerbera plants responded quadratically to nitrogen dosages, with a maximum flower diameter of 10 cm at a dosage of 0.14 g N L^{-1} substrate [3]. Jadhao et al. [4] stated that, as nitrogen levels increased, the number of leaves on $plant^{-1}$ increased. Maximum expansion was obtained by applying 30g of nitrogen per square metre monthly.

Unfortunately, the overuse of chemical fertilisers damages the flora, fauna, and enzymes in the soil, which lowers the natural fertility of the soil and reduces their activity [5]. Leaching of fertilisers into water can potentially be hazardous to the environment [6]. It is past time to consider other crop nutrition options in order to reduce our reliance on chemical fertilizers entirely.

Composting improves soil stability, water holding capacity, plant water availability, reduces nutrient leaching, and reduces erosion and evaporation [7]. Although adding cattle manure to the soil increases the amount of phosphorus available for growing potted gerberas, it has no effect on the commercial quality of the flowers [8].

As an excellent organic fertiliser and soil conditioner, compost made from organic household wastes provides the soil with nutrients and organic materials, which enhances soil structure, aggregate stability, and water-holding capacity, gives plants vital nutrients, including micronutrients. Thermochemical organic fertiliser (TOF), a type of organic fertiliser, is made from degradable waste through thermochemical processing by the Department of Soil Science and Agricultural Chemistry at the College of Agriculture in Vellayani. The quality of this product is comparable to that of conventional composts. TOF contains macronutrients 2.01± 0.11% N, 0.95 ± 0.15% P and 1.1±0.20% K in addition to secondary nutrients (Ca, Mg, S) and micronutrients (Mn, Zn, Cu, and B) [9].

Leno et al. [10] stated that, due to its physico-chemical characteristics and nutrient content, fortified manure created using rapid conversion technology satisfies the requirements for being a full organic fertiliser. The soil organic carbon pool could be significantly increased by employing thermochemical digestate fertiliser [11].

The nutrient use efficiency of conventional chemical fertilizers for N, P, and K, respectively, seldom exceeds 30–35%, 18–20%, and 35–40%. Utilizing nano-fertilizers is a wise option for increasing fertilizer use efficiency. Nutrient carriers known as nano-fertilizers are being created employing substrates with nanoscale diameters between 1 and 100 nm. The significant surface area of nanoparticles enables them to store large amounts of nutrients and release them gradually and consistently, allowing crops to absorb the nutrients they need without having any negative side effects that arise with using specialized fertilizer inputs [12]. Nanoparticles, which are non-toxic and less dangerous for people and the environment than conventional fertilisers, increase soil fertility, crop yield, and quality metrics. They also reduce expenses and maximise profit [13].

The "Nano Urea Liquid" product was developed at the IFFCO's Nano Biotechnology Research Center (NBRC) in Kalol, Gujarat. When compared to conventional nitrogen fertilisers, the foliar application of nano urea at key crop growth phases successfully satisfies a plant's nitrogen requirement, increasing crop productivity and quality [14]. Regular urea can be replaced with nano urea, which can at least 50% lessen the requirement for it [15].

In lettuce, the high rate of nano nitrogen (50%) significantly increased vegetative development in terms of plant fresh weight, leaf area, head fresh weight, size of head size, firmness, total yield, and marketable yield [16]. Where there is a shortage of urea, the foliar treatment of nano urea may be advantageous when utilised after applying basal 50% urea [17].

In line with Kumar and Chaudhary [18], combining chemical fertilisers with organic and biofertilizers boosts soil fertility in flower crops while also enhancing the growth, blooming, and production of floricultural crops. This approach also offers the highest net returns.

Keditsu [19] found that the treatment of 50% RDF (60:40:60 kg N, P_2O_5, K_2O ha^{-1}) plus 25% pig manure plus 25% FYM generated the greatest number of leaves (13.21 $plant^{-1}$) in Gerbera. Treatments like 50% RDF + 50% FYM and 50% RDF + 50% pig manure both resulted in significantly greater flower yields of 2.63 and 2.49 kg per square metre, respectively. In the experiment by Rajib et al. [20], among the several treatments, the treatment that included organic and inorganic fertilisers produced most leaves (17.00), the longest leaf length (28.40cm), and the widest leaf breadth (6.96cm) in Gerbera.

Given the aforementioned, we conducted a study to assess the effects of combined application of nano urea liquid fertiliser (created by IFFCO) and custom blended thermochemical organic fertiliser (produced by KAU) on growth and yield of gerbera in order to achieve sustainable production of gerbera (*Gerbera jamesonii* Bolus) with minimal detrimental effect of chemical fertilisers on soil health and to increase fertiliser usage efficiency.

2. METHODOLOGY

The experiment was conducted in 2021-2022 inside naturally ventilated polyhouse in the Department of Floriculture and Landscaping, College of Agriculture, Vellayani using 3-month-old tissue culture plantlets of gerbera variety 'Natasha'. The experiment was laid out in CRD with 10 treatments and 15 replications. For the treatments from T_1 to T_8, growbags were filled with soil, coir pith and thermochemical organic fertilizer (TOF) in 1:1:1 proportion on volume basis. The potting mixture comprising equal proportion of soil and coir pith was used for the absolute control (T_{10}). Potting mixture containing equal proportion of soil, sand and coir pith along with PGPR 1 @ 2% of the substrate was used for the control (T_9) [21].

The treatments T_1 to T_8 were applied at fortnightly intervals starting from 3 weeks after planting. Top dressing for T_1 to T_8 was done with custom blended thermochemical organic fertilizer (CBF), which was produced through the patented suchitha technology. Custom blending was done in three modes ie., blending with rajphos and MOP (CBF-PK), blending with nano-urea, rajphos and MOP (CBF-NPK) and blending with urea, rajphos and MOP (CBF-UPK). Fertilizer application was restricted to supply nutrients in 2 doses ie, 1 g N: 0.8 g P_2O_5: 1.6 g K_2O (T_1 to T_4) or 1.2 g N: 0.8 g P_2O_5: 2 g K_2O (T_5 to T_8) per plant at fortnightly intervals starting from 3 weeks after planting. Top dressing was done with foliar nano urea and soil application of CBF-PK (for T_1 and T_5), soil application of CBF-NPK (for T_2 and T_6), foliar urea and soil application of CBF-PK (for T_3 and T_7) and soil application of CBF-UPK (for T_4 and T_8). The control plants were maintained by monthly soil application of 1.6g N, 1.6 g P_2O_5 and 1.6 g K_2O, bimonthly application of 30 g dried cow dung manure and bimonthly foliar application of 13:27:27 (0.4%) @ 100 ml per plant.

The measured vegetative parameters include plant spread, number of leaves per plant and number of suckers per plant; floral characters include flower diameter and bloom life; yield parameter include number of flowers produced $plant^{-1}$ $month^{-1}$. The data recorded for different treatments during the experimental period was statistically analysed. ANOVA (analysis of variance) for CRD (completely randomized design) was worked out and the results were interpreted. GrapesAgri1 was utilised for analysis of data [22].

3. RESULTS AND DISCUSSION

The plant spread significantly differed among the treatments (Table 1). The highest value for plant spread (152.17cm) was recorded in the treatment T_5 (foliar application of nano urea and soil application of thermochemical organic fertilizer custom blended with rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O) followed by T_1 (142.65cm) which was on par with T_7 (142.49cm). The lowest value for plant spread was recorded for the treatment T_9 (105.49cm). The increase in plant spread might be due to the improved nitrogen availability brought on by the application of nano urea. Growing parameters of lettuce were increased by using foliar nano urea spray. It was found that foliar spray with 2500 mg of nano-urea N l^{-1} was more effective than foliar spray with 5000 mg of regular urea N l^{-1} [23].

Significant difference was noticed among the treatments for number of leaves per plant and it ranged from 6.86 to 12.58 (Table 1). Number of leaves was found to be the highest (12.58) in the treatment T_5 (foliar application of nano urea and soil application of thermochemical organic fertilizer custom blended with rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O) which was significantly superior to other treatments. T_{10} (absolute control) recorded the lowest number of leaves (6.86). In gerbera, [24] observed a marked increase in the number of leaves per plant as the nitrogen levels increased, which in turn contributed to the plant's robust vegetative development. Abdel-Salam [23] reported that in lettuce, there was an increase in the number of leaves by the application of nano- urea. Nano urea might have enhanced the production of chlorophyll, which speeded up photosynthesis and improved overall plant growth, possibly leading to the development of more leaves as reported by Midde et al. [25].

Leaf length exhibited significant difference among the treatments (Table 1). The longest leaf (31.09 cm) was noticed in the treatment T_5 which was followed by T_1, T_7 and T_3 which recorded 29.76 cm, 29.13 cm and 28.40 cm respectively. The lowest leaf length was recorded in T_{10} (21.33 cm). Leaf morphology is significantly influenced by the nutrient availability [26]. When cultivated in high nutrient availability situations, plants develop larger, shorter-lived leaves with higher nitrogen concentrations per unit area than when produced in low nutrient availability situations [27]. Photosynthetic efficiency of the plant is enhanced by increased leaf length. This might be due to the fact that if the nutrients are supplied at regular intervals, plants receive proper nutrition and they perform better. Deshmukh et al. [28] also reported that the timely delivery of adequate quantities of fertilizers encourages physiological processes like photosynthesis and cell division, which improves plant growth.

Leaf breadth was significantly higher (9.53 cm) in the treatment T_3 (foliar application of urea and soil application of thermochemical organic fertilizer custom blended with rajphos and MOP @ 1 g N: 0.8 g P_2O_5: 1.6 g K_2O). It was immediately followed by T_1 (9.34 cm) which was on par with T_8 (9.31 cm) and T_7 (9.24 cm) (Table 1). The lowest leaf breadth (6.73 cm) was for treatment T_{10}. This might be due to the increase in availability of nitrogen through the foliar application of urea and absolute balance between nitrogen and organic carbon equilibrium. Proper phosphorous availability influences increased leaf breadth [29]. Although the longest leaves were observed in T_5, leaf breadth was significantly low (only 9.16 cm) when compared to T_3 (9.53 cm). This result is consistent with the findings of Sseremba et al. [30], who concluded that an increase in leaf length would not necessarily cause an increase in leaf blade width.

The largest leaf area (142.39 cm^2) was obtained for the treatment T_5 which was followed by T_1(139.10 cm^2). T_3 and T_7 recorded 135.29 cm^2 and 134.61 cm^2 respectively (Table 1). The lowest leaf area (71.72 cm^2) was recorded for the treatment T_{10}. The combined application of all the primary nutrients might have increased cell division and cytokinin synthesis, thereby increasing the leaf area as reported by Hirose et al. [31]. Moreover, nano fertilizers primarily extend the fertilizer effect period and prolong the release of nutrients. The use of all nutrients in combination, whether in nano or conventional formulation, was considerably superior to the use of each nutrient alone. According to Palanisamy et al. [32], the varieties, nutrient treatments and level of split application of nutrients had significant effect on leaf area of gerbera. The Flame Seedless grapevines, which underwent three applications of 0.2% amino-mineral nanofertilizer for two seasons, showed the highest values for leaf area [33].

The highest number of suckers per plant (1.49) was produced in the treatment T_5 (foliar application of nano urea and soil application of thermochemical organic fertilizer custom blended with rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O) which was followed by T_1 (1.21) (Table 1).

Table 1. Effect of treatments on vegetative characters of *Gerbera jamesonii* bolus var. natasha

Treatments	Plant Spread (cm)	No. of leaves plant^{-1}	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2)	No. of suckers plant^{-1}
T_1	142.65	11.41	29.76	9.34	139.11	1.21
T_2	133.54	8.17	25.46	9.05	115.09	0.65
T_3	141.42	10.69	28.40	9.53	135.29	0.99
T_4	137.16	9.30	26.64	9.10	121.22	0.74
T_5	152.17	12.58	31.09	9.16	142.39	1.49
T_6	139.86	9.49	27.83	9.15	127.38	0.85
T_7	142.49	10.85	29.13	9.24	134.61	1.11
T_8	138.67	9.76	27.31	9.31	127.09	0.93
T_9 (Control)	105.49	7.22	22.05	8.51	93.76	0.49
T_{10} (Absolute control)	108.05	6.86	21.33	6.73	71.72	0.44
SEm (±)	0.263	0.068	0.162	0.059	1.055	0.016
CD (0.05)	0.734	0.19	0.454	0.165	2.949	0.044

Table 2. Effect of treatments on floral parameters of *Gerbera jamesonii* bolus var. natasha

Treatments	Bloom life (days)	Flower diameter (cm)	Length of flower stalk (cm)	Girth of flower stalk (cm)	No. of flowers per plant (monthly)
T_1	6.03	6.29	29.93	0.93	1.73
T_2	6.31	6.51	29.71	0.93	1.67
T_3	6.72	6.75	29.77	0.96	1.79
T_4	6.69	6.59	29.24	0.93	1.70
T_5	10.35	7.38	31.16	1.03	2.19
T_6	10.37	7.48	31.01	1.06	2.18
T_7	10.51	7.45	30.93	1.06	2.27
T_8	11.75	7.73	33.77	1.05	2.49
T_9 (Control)	7.42	6.14	27.57	0.93	1.59
T_{10} (Absolute control)	3.39	3.06	11.99	0.72	0.52
SEm (±)	0.098	0.082	0.159	0.011	0.032
CD (0.05)	0.273	0.231	0.445	0.03	0.088

The treatment T_{10} produced the least number of suckers per plant (0.44). This is in line with the findings of Fayz et al. [34], which concluded that when nutrients were applied at optimum levels, number of suckers increased. Sucker production is dependent on the nutritional status of the mother plant. Greater uptake of nutrients especially nitrogen might have resulted in more sucker production.

Bloom life exhibited significant difference among the treatments (Table 2 & Fig. 1). T_8 (soil application of thermochemical organic fertilizer custom blended with urea, rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O) recorded the longest bloom life (11.75 days) followed by T_7 (10.51 days) which was on par with T_6 (10.37 days) and T_5 (10.35 days). The shortest bloom life (3.39 days) was observed in the absolute control (T_{10}). The availability of balanced nutrition might be the reason for increased bloom life. Amin et al. [35] concluded that increased rates of phosphate and potassium fertilizers greatly lengthened the blossom life of gerbera plants. According to Fayz et al. [34], the flower longevity was highly influenced by different doses of NPK. A nutrient treatment 20:20:15 NPK g m^{-2} resulted in maximum flower longevity (23.5 days). Srivastava et al. [36] also observed a gradual increase of flower longevity (12.87-15.77 days) with an application of fertilizer doses in between the range 0 - 45g NPK m^{-2} $month^{-1}$.

Diameter of fully opened flowers showed significant variation among the treatments (Table 2). T8 produced flowers of largest diameter (7.73 cm) followed by T_6 (7.48 cm) which was on par with T_7 and T_5 which recorded 7.45 cm and 7.38 cm respectively. The smallest flowers were produced in the treatment T_{10} (3.06 cm). This might be the result of optimum use of fertilizers. Ayemi et al. [37] reported that Increased potassium, a major osmotically active component that contributes to cell turgor and increases the capacity of plant cells to retain water and nutrients, may be the cause of the substantially maximum bloom diameter. Potassium may have contributed to the higher floral diameter quality by enhancing photosynthetic efficiency. In gerberas, nitrogen and phosphorus also produced a huge increase in nutrient uptake and induced flowering, which in turn yielded the largest achievable flower diameter.

T8 produced flowers with longest stalk (33.77cm) followed by T5 (31.16cm) which was on par with T6 and T7 which recorded 31.01cm and 30.93 cm respectively (Table 2). Flowers with shortest stalk were produced by T10 (11.99 cm). Possible factors that contributed to the elongation of the flower stem include the production of growth-promoting substances such as gibberellic acid [38]. Panj et al. Panj et al. [39] recorded a positive and significant correlation between

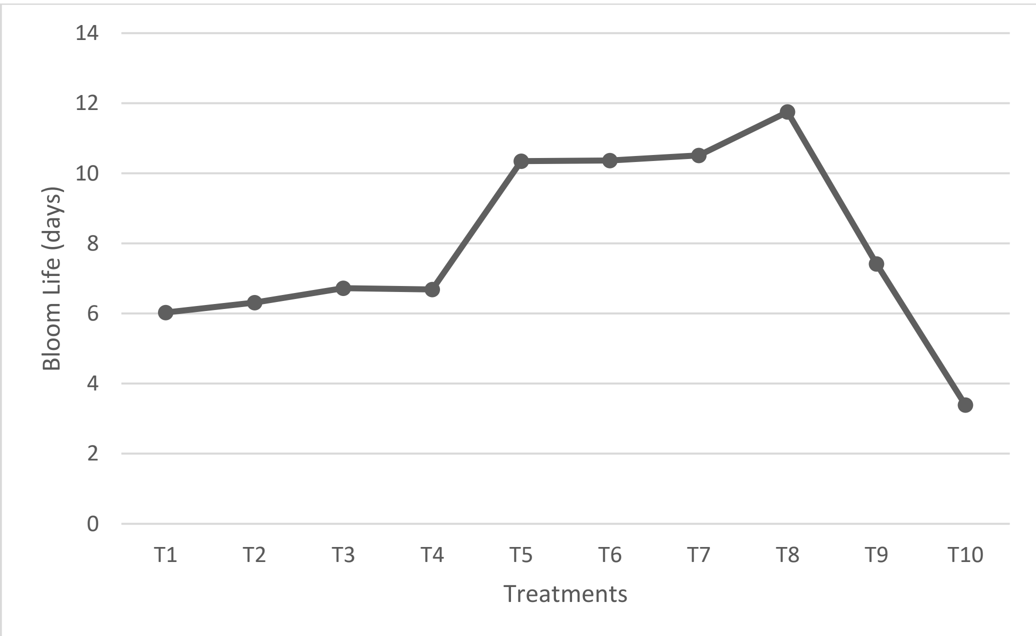

Fig. 1. Effect of treatments on bloom life (days)

length of the flower stalk in gerbera and percentage NPK content which supports the present finding. The length of the stalk varies between cultivars and is typically referred to as a genetic cause. The amount of food materials accumulated in the flower stalk may cause variations [40]. Higher stalk length (39.6 cm) was achieved in gerbera plants after applying both organic and inorganic fertilizer [20].

Girth of flower stalk in treatment T_6 (soil application of thermochemical organic fertilizer custom blended with nano urea, rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O) and T_7 (foliar application of urea and soil application of thermochemical organic fertilizer custom blended with rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O) recorded the highest value for girth of flower stalk (1.06 cm) which was on par with T_8 (1.05 cm) and T_5 (1.03 cm). The lowest girth (0.72 cm) was recorded by T_{10}. According to [38], girth of the flower stalk in gerbera plants was positively and significantly correlated with EC, Organic carbon content and accessible N, P, and K. According to Biswal et al. [40], the difference in the diameter of flower stalks may be caused by the quantity of food materials stored inside the flower stalk. Palanisamy et al. [32] reported that the combination of NO_3^- and NH_4^+ might have boosted nutrient uptake, particularly nitrogen, and thus expanded the girth of the flower stem.

The total number of flowers produced were recorded per plant on monthly basis. There was significant difference among the different treatments in the number of flowers produced per plant per month (Table 2 & Fig 2). T_8 produced the highest number of flowers per plant per month (2.49) followed by T7 (2.27). The lowest number of flowers per plant per month was recorded for T10 (0.52). This is in conformity with results of Deshpande et al. [41]. He found out that the number of flowers increased with an increase in the application of potassium in gerbera. According to Thangam et al. [42], gerbera produced more flowers in media with higher nitrogen, phosphorus, and potassium levels. The flower yield increase might be attributed to the larger leaf area, more leaves per plant and plant spread, which led to the synthesis and accumulation of the most photosynthates, leading to the creation of more flowers with larger sizes [43]. According to Palanisamy et al. [32], a rise in the amount of mineral constituents and balanced nutrition might have aided the production of a greater number of flowers. Number of flowers produced per plant was recorded throughout the experimental period and it was found that a greater number of flowers were produced during 5th and 6th month after

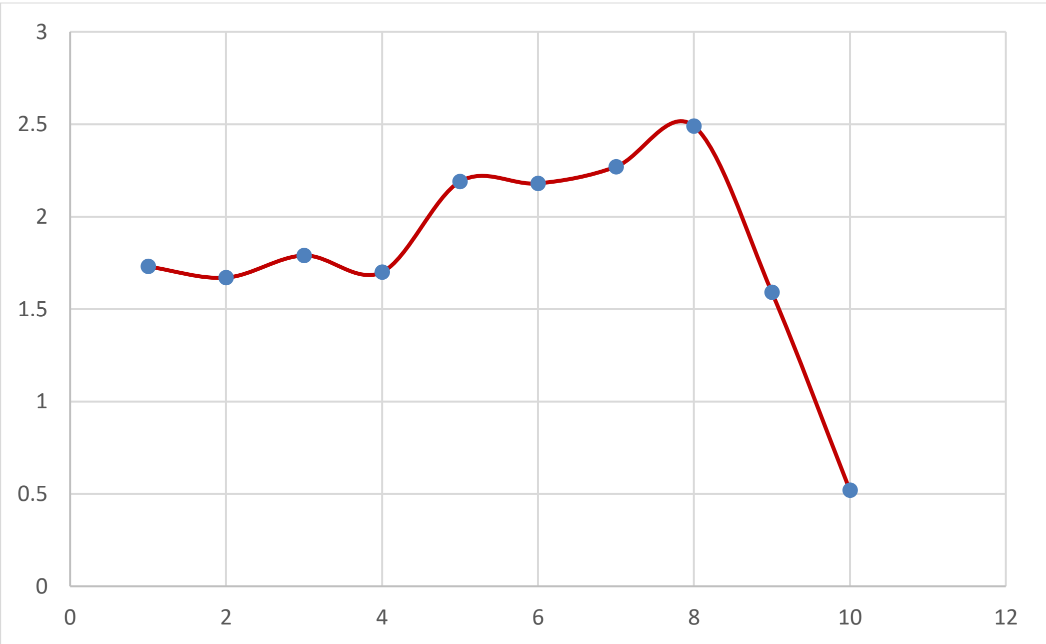

Fig. 2. Effect of treatments on number of flowers produced per plant per month

planting. This result is in conformity with the findings of Sankar [43]. He claims that the peak bloom supply was seen up to five to six months after planting. According to Irshana [44], under protected culture, the highest number of flowers was obtained during rainy season. This supports the results of the present study.

4. CONCLUSION

Treatment T_5 (Fortnightly foliar application of nano urea and soil application of thermochemical organic fertilizer custom blended with rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O per plant) was found to be significantly superior and recorded the highest values for vegetative parameters like plant spread (152.17 cm), number of leaves per plant (12.58), leaf length (31.09 cm) and leaf area (142.39 cm^2). However, leaf breadth (9.53 cm) was significantly higher in T_3 (foliar application of urea and soil application of thermochemical organic fertilizer custom blended with rajphos and MOP @ 1 g N: 0.8 g P_2O_5: 1.6 g K_2O per plant). The highest number of suckers per plant (1.49) was also recorded in T_5. T_8 (soil application of thermochemical organic fertilizer custom blended with urea, rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O) recorded the longest bloom life (11.75 days), the largest flower diameter (7.73 cm) and the longest flower stalk (33.77cm). T_6 (soil application of thermochemical organic fertilizer custom blended with nano urea, rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O) and T_7 (foliar application of urea and soil application of thermochemical organic fertilizer custom blended with rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O) recorded the highest girth of flower stalk (1.06 cm) and were on par with T_5 and T_8. Soil application of thermochemical organic fertilizer custom blended with urea, rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O (T_8) produced the highest number of flowers per plant per month (2.49) and it was followed by T_5.

To conclude with, the results of the study revealed that fortnightly foliar application of nano urea and soil application of thermochemical organic fertilizer custom blended with rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O per plant improved all vegetative parameters in gerbera variety 'Natasha' except leaf breadth and soil application of thermochemical organic fertilizer custom blended with urea, rajphos and MOP @ 1.2 g N: 0.8 g P_2O_5: 2 g K_2O per plant significantly improved floral parameters like flower diameter, length of flower stalk , flower yield, bloom life and visual appeal.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Rao TM, Kumar R. Production technology of flower crops – A Hand book. ICAR-IIHR, Bengaluru; 2019.
2. Riaz A, Younis A, Ghani I, Tariq U, Ahsan M. Agricultural waste as growing media component for the growth and flowering of *Gerbera jamesonii* cv. hybrid mix. Int J Recycl Org Waste Agric. 2015;4(3):197-20 4.
3. Milani M, Pradella EM, Heintze W, Schafer G, Bender RJ. Nitrogen and calcium fertilization on the growth and development of gerbera cultivated in pots for cut flowers. Ornamental Hortic. 2021;27:288-295.
4. Jadhao A, Tamgadge M, Deshmukh A, Telgote N, Bodakhe V. Effect of nitrogen levels and gibberellic acid on growth and yield of gerbera under polyhouse condition. Asian J Hortic. 2010;5(2):341-343.
5. Gupta R, Yadav A, Garg VK. Influence of vermicompost application in potting media on growth and flowering of marigold crop. Int J Recycl Org Waste Agric. 2014;3 (1):47.
6. Majumder J, Perinban S, Tiwari AK, Saha TN, Kumar R. Integrated nutrient management in commercial flower crops. Progressive Res. 2014;9(1): 28-32.
7. Adugna G. A review on impact of compost on soil properties, water use and crop productivity. Academic Res J Agric Sci Res. 2016;4(3):93-104.
8. Mantovani JR, Silveira LGD, Landgraf PRC, Santos ARD, Costa BDS. Phosphorus rates and use of cattle manure in potted gerbera cultivation. Ornamental Hortic. 2017;23:412-418.
9. Sudharmaidevi CR, Thampatti KCM, Saifudeen N. Rapid production of organic

fertilizer from degradable waste by thermochemical processing. Int J Recycl Org Waste Agric. 2017;6:1-11.

10. Leno N, Sudharmaidevi CR, Meera AV. Fertility evaluation and manurial effect of organic manure produced from degradable solid waste by rapid conversion technology. Adv Life Sci. 2016;5(11):4433-4436.
11. Leno N, Ajayan AS, Thampatti KCM, Sudharmaidevi CR, Aparna B, Gladis R, et al. Humification evaluation and carbon recalcitrance of a rapid thermochemical digestate fertiliser from degradable solid waste for climate change mitigation in the tropics. Sci Total Environ. 2022;849:157 752.
12. Preetha PS, Balakrishnan N. A review of nano fertilizers and their use and functions in soil. Int J Curr Microbiol App Sci. 2017; 6(12): 3117-3133.
13. Qureshi A, Singh DK, Dwivedi S. Nano-fertilizers: a novel way for enhancing nutrient use efficiency and crop productivity. Int J Curr Microbiol App Sci. 2018;7(2): 3325-3335.
14. Kumar R, Singh RK, Panda A, Singh SK. Nano Urea: An efficient tool for precision agriculture and sustainability. Vigyan Varta. 2021;2(9):72-74.
15. Kantwa S, Yadav LR. Nano urea: Applications and significance. Just Agric. 2022;2:1-6.
16. Nofal AS, Helaly AA, Ashmawi AE, Mohammed AA, El-Abd MT. Effect of soil application of nano NPK fertilizers on growth, productivity and quality of Lettuce (*Lactuca sativa*). Al-Azhar J Agric Res. 2021;46(1):91-100.
17. Goud G, Madhavi A, Pasha M, Sudhakar KS. Evaluation of the foliar application of nano urea on the performance of rabi sunflower (*Helianthus annuus* L.). Int J Environ Clim Change. 2022;12(11):2700-2706.
18. Kumar M, Chaudhary V. Effect of integrated sources of nutrients on growth, flowering, yield and soil quality of floricultural crops: A review. Int J Curr Microbiol App Sci. 2018;7(3):2373-2404.
19. Keditsu R. Response of gerbera to inorganic fertilization versus organic manuring. Ann Pl Soil Res. 2012;14(2): 163-166.
20. Rajib MMR, Jui SA, Hossain MM, Saikat MMH, Haque MA. Gerbera genotypes as performed under different soil amendments. Am J Agric Sci Eng Technol. 2017;4(1).
21. Anaswara SJ. Nutrient management in gerbera (*Gerbera jamesonii* Bolus.) grown under naturally ventilated polyhouse. M.Sc. (Hort.) thesis, Kerala Agricultural University, Thrissur. 2018.
22. Gopinath PP, Prasad R, Joseph B, Adarsh VS. grapesAgri1: Collection of shiny apps for data analysis in agriculture. J Open-Source Software. 2021;6(63):3437.
23. Abdel-Salam M. Response of lettuce (*Lactuca sativa* L.) to foliar spray using nano-urea combined with mycorrhiza. J Soil Sci Agric Eng. 2018;9(10):467-472.
24. Rashid MH, Rayhan MR. Effects of varieties and inorganic fertilizers on growth and flowering of gerbera (*Gerbera jamesonii*). J Agric Food Environ. 2020; 1(4): 6-12.
25. Midde SK, Perumal MS, Murugan G, Sudhagar R, Mattepally VS, Bada MR. Evaluation of nano urea on growth and yield attributes of rice (*Oryza Sativa* L.). Chem Sci Rev Letters. 2022;11(42): 211-214.
26. Niinemets U, Sack L. Structural determinants of leaf light-harvesting capacity and photosynthetic potentials. Prog Bot. 2006;385-419.
27. Oikawa S, Hikosaka K, Hirose T. Leaf lifespan and lifetime carbon balance of individual leaves in a stand of an annual herb, Xanthium canadense. New Phytologist. 2006;172(1):104-116.
28. Deshmukh M, Gupta NS, Deshmukh SD, Gawande P, Raut VU. Eminent flowering gained via split application of NPK. Int J Curr Microbiol App Sci. 2018;6:2144-2150.
29. Mer R. Effect of nitrogen, phosphorus and potassium on vegetative and floral attributes in bird of paradise (*Strelitzia reginae* Ait.). M.Sc. (Hort.) thesis, G. B. Pant University of Agriculture and Technology, Pantnagar; 2014.
30. Sseremba G, Tongoona P, Eleblu JSY, Danquah EY, Kaweesi T, Baguma Y, et al. Stability of Solanum aethiopicum Shum accessions under varied water deficit stress levels and identification of pertinent breeding traits for resistance to water shortage. Euphytica. 2018; 214(1):1-11.
31. Hirose N, Takei K, Kuroha T, Hayashi H, Sakakibara H. Regulation of cytokinin biosynthesis, compartmentalization and translocation. J Exp Bot. 2007;59(1):75–83.

32. Palanisamy, Kannan D, Sharma R, Bhatt SS, Singh A. Fertigation studies in gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) for growth and yield under cover in southern hills. Int J Trop Agric. 2017;33(1):29-34.
33. Wassel AEH, El-Wasfy M, Mohamed M. Response of Flame seedless grapevines to foliar application of nano fertilizers. J Productivity Develop. 2017;22(3):469-485.
34. Fayz K, Singh D, Singh VK, Bashir D, Kuller LR. Effect of NPK on plant growth, flower quality and yield of gerbera (*Gerbera jamesonii*). Res Environ Life Sci. 2016;9(11):1361-1363.
35. Amin N, Sajid M, Sajid M, Qayyum MM, Shah ST, Fazl-i-Wahid RSH. Response of gerbera (*Gerbera jamesonii*) to different levels of phosphorus and potassium. Int J Biosciences. 2015;7(4):1-11.
36. Srivastava R, Kumari J, Negi N, Chand S. Evaluation of NPK doses and varieties on vegetative and floral characters of offshoot propagated gerbera (Gerbera jamesonii) plants under shade net conditions. Int. J. Chem. Stud. 2017; 5(5):1888-1891.
37. Ayemi TJ, Singh D, Fatmi U. Effect of NPK on plant growth, flower quality and yield of Gerbera (*Gerbera jamesonii* L.) cv. Ruby Red under naturally ventilated polyhouse condition. Int J Curr Microbiol Appl Sci. 2017;6(8):1049-1056.
38. George E. Integrated nutrient management on growth, flower yield and postharvest quality of gerbera (*Gerbera jamesonii* Bolus.) cv. Galileo red under poly house condition. M. Sc (Hort.) thesis, University of agricultural sciences, Bangalore. 2012.
39. Panj FG, Kumari S, Parmar PB. Effect of growing media properties and its correlation study in Gerbera production. Bioscan. 2014;9(1):79-83.
40. Biswal M, Palai SK, Chhuria S, Sahu P. Evaluation of Exotic Cultivars of Gerbera (*Gerbera jamesonii* L.) under Naturally Ventilated Polyhouse in Western Odisha. J Krishi Vigyan. 2017;5(2):70-76.
41. Deshpande RM, Dalal SR, Gonge VS, Mohariya AD, Anuje AA. Effect of phosphorus and potash on growth, flowering and yield of gerbera under polyhouse conditions. Crop Res. 2005; 29(2):268-271. 42. Thangam M, Ladaniya MS, Korikanthimath VS. Performance of gerbera varieties in different growing media under coastal humid conditions of Goa. Indian J Hortic. 2009;66(1):79-82.
42. Salem RAA, Saravanan S, Prasad VM. Effect of Benzyl Adenine on growth, yield and flowers of Gerbera (*Gerbera jamesonii*). Int J Eng Sci Res Technol. 2016;5(3):108-114.
43. Sankar M. Varietal evaluation of gerbera (*Gerbera jamesonii* Bolus) under low cost greenhouse. M.Sc. (Hort.) thesis, Kerala Agricultural University, Thrissur; 2003.
44. Irshana MP. Evaluation of gerbera (*Gerbera jamesonii* Bolus) varieties for rain shelter cultivation. M.Sc. (Hort.) thesis, Kerala Agricultural University, Thrissur; 2016.

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