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Effect of nano fertilizers and liquid micronutrients on flowering and yield attributes of gerbera under shade net condition

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ABSTRACT

The investigation was conducted with an aimed to study the effect of nano fertilizers (nano urea, nano diammonium phosphate) and liquid micronutrients on flower yield and flower quality of gerbera (*Gerbera jamesonii)* cv. Toro Rosso under shade net conditions during the late winter seasons of the year 2024-2025. This study involved seven treatments in a completely randomized design with three replications. Among different treatments T_6 was significantly resulted with minimum number of days taken to first flower bud initiation (45.73 days), days taken to first flower bud opening (65.20 days), scape bending curvature (11.42°) and maximum flower diameter (11.93 cm), flower stalk length (64.17 cm), flower stalk diameter (8.30 mm), fresh weight of flower (34.5 g), longevity of flowers on the plant (15.53 days), vase life in distilled water (9.06 days), flower yield per plant (2.40) and maximum total flower yield per plant at the 150 days after planting (7.13) was recorded in June, 2024. Based on the significant results from the study it was concluded that foliar application of nano fertilizers and liquid micronutrients of T_6 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Liquid micronutrients @ 2.5 ml/L (Fortnight intervals from 30 days onwards up to 150 days)] was best for all the flower, flower yield and quality attributes of gerbera.

Key words: *Gerbera jamesonii*, shade net, nano urea, nano DAP, micronutrients, flower quality.

INTRODUCTION

In recent decades, the floriculture industry has become a grater sunrise Horti-business venture worldwide and the floricultural gardens are also has been immense expanded with rapid transformation due to the changing consumer preferences, popularity of environment-friendly lifestyles, climate variability, labour shortage and the use of environmentally safe nano fertilizer for cultivation (Jena *et al*., 9). The cultivation of gerbera with over use of inorganic fertilizers often leads to degradation of land properties, environment pollution, soil pollution, water pollution, increases crop production cost and inconsistent with flower yields and quality. To minimizing of these problems, the integration of emerging cutting-edge technologies like nano fertilizers (nano urea, nano DAP) and liquid micronutrients along with solid-inorganic fertilizers play a significant role for sustainable floriculture and that allow the optimum supply of nutrients to crop plants and averting degradation of environment, minimizes the fertilizers quantities, control the use of excess chemicals, reduces cost of cultivation and with profitable income (Ditta, 8). Nano urea contains 4% nanoscale nitrogen (higher number of particles with larger surface area about 10,000 times more than 1 mm urea prill) by weight in its nano form, effectively meeting crop nitrogen demands with better fertilizer use efficiency than conventional urea. The topical application of environmental-friendly nano urea (liquid) on the crop plants enhances crop yield, biomass, nutritional quality of the produce and also improves the soil health and water quality. it is cheaper than conventional urea, reducing input costs for farmers and potentially decreasing the use of conventional urea by 50% or more (Baboo, 3). The nano DAP (nano nitrogen and phosphorus) formulation contains 8.0% nitrogen w/v, 16.0% P_2O_5 w/v and with the particle size of less than 100 nm (nanometres). It has unique characteristic feature *i.e*. higher surface area to volume ratio, that allows easily penetration through stomata and other plant openings leads to better distribution and assimilation of nano DAP within plant systems. Ultimately, improves the chlorophyll content and photosynthetic efficiency (https://www.iffco.in/en/nano-dap-liquid). And the foliar application of different amounts of nano-scale micronutrients to the crop plants has a substantial impact on their physiological and biochemical properties, such as the quantity of chlorophyll production that controls photosynthesis (Avilala *et al*., 2). In the international

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cut flower trade currently, gerbera occupies the fourth rank position and it can contribute largely to the floriculture industry through their yield potential, colour variation, long vase life and even also suitability for long-distance transport (Chauhan, 6). Gerbera (*Gerbera jamesonii* Bolus Ex. Hooker F.) is one of the herbaceous perennial cut flower plants with leafless long flower stalk and daisy like flower, popularly grown for cut flower in a wide range of tropical to subtropical climatic regions of the world and commonly called as Barberton daisy, Transvaal daisy or African daisy. it was originated in South Africa and belongs to the asteraceae family. The gerbera plants are stemless, leaves with arranged in a rosette at the base, flower heads solitary but many flowered with conspicuous ray florets in one or two rows and widely suited for bouquets, floral arrangements, interior decoration, flower beds, borders, pots, window boxes and gardens (Bhuiyan *et al*., 4). As keeping the above information on the influence of nanoscale fertilizers and micronutrients on growth, yield and quality of gerbera flowers is very limited. Hence, the present research work was planned with an objective of to know the effect of nano urea, nano DAP, in combination with liquid micronutrients on flowering and yield attributes of gerbera.

MATERIALS AND METHODS

The experiment was conducted at Floricultural research block, College of Horticulture, Rajendranagar, Ranga Reddy district, Telangana, Sri Konda Laxman Telangana Horticultural University, during the late winter season of the year 2024-2025. The investigated location falls under semi-arid tropical climate with an average precipitation of 615.6 mm, positioned at an elevation of 542.3 m. above sea level at a latitude of 17.90º N and a longitude of 78.23º E. The experimentation was planned in a green shade net with 50% ventilation by following the statistical design of completely randomized design with three replications and seven treatments; T_1:[100% RDF (Control)], T_2:[75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3ml/ L], T_3:[50% N + 50% P_2O_5 + 100% K_2O + nano DAP @ 3ml/L], T_4:[75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3ml/L + Micronutrients (Solid form) @ 5 g/L], T_5:[50% N + 50% P_2O_5 + 100% K_2O + nano DAP @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L], T_6:[75% N + 75% P_2O_5 +100% K_2O + nano urea @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L], T_7:[50% N + 50% P_2O_5 + 100% K_2O + nano DAP @ 3 ml/L + liquid micronutrients @ 2.5 ml/L]. The data collection was carried out on five randomly tagged plants per treatment and data was statistically analysed with R- Software statistical tools. The healthy and uniform sized tissue cultured plants of gerbera (var. Toro Rosso), each with four to five leaved were planted [(Middle of the media contained pot) in the growing media (Cocopeat: vermicompost: red earth (1:1:1)] filled plastic pots and the top active growing bud of plant was positioned two centimetres above the potting soil without disrupting the roots. The different levels (50%, 75% 100%) of nitrogen (N), phosphorous (P_2O_5) and potash (K_2O) for gerbera were initially applied ten days after planting and following this, the nutrients were administered monthly accordingly using inorganic fertilizers *viz*., ammonia, single super phosphate and sulphate of potash. The foliar application of nano fertilizers (nano urea, nano DAP) and micronutrients was applied at every fortnight interval from 30 days onwards up to 150 days duration of the crop investigation.

RESULTS AND DISCUSSION

The results depicted in Table 1 revealed the effect of nano urea, nano DAP and micronutrients on flowering attributes *viz*., number of days taken to first flower opening (Days), number of days taken to first flower opening (Days) of gerbera. The minimum number of days taken to first flower bud initiation was recorded in T_6 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Liquid micronutrients @ 2.5 ml/L (Fortnight intervals from 30 days onwards up to 150 days)] with (45.73 days) followed by T_4 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Micronutrients (Solid form) @ 5 g/L (Fortnight intervals from 30 days onwards up to 150 days)] with (49.73 days). The maximum number of days taken to first flower bud initiation was noticed in T_1 (control) with (57.33 days). The minimum number of days to first flower bud initiation was recorded in T_6, which may be attributed to the foliar application of nano urea and liquid micronutrients. These treatments likely enhanced photosynthetic efficiency, regulated auxin (IAA) metabolism, and stimulated protein synthesis, thereby improving physiological and metabolic activities that favor early floral induction and bud initiation. Comparable findings have been reported by Mounika *et al.* (12), Sunil *et al.* (15), Kashif *et al.* (10), and Ahmad *et al.* (1), who also observed accelerated flowering in response to improved nutrient management practices.

The significant results were observed among all treatments, minimum number of days required for first flower opening was noticed in T_6 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Liquid micronutrients @ 2.5 ml/L (Fortnight intervals from 30 days onwards up 150 days)] with (65.20

Table 1: Effect of nano urea, nano DAP and micronutrients on number of days taken to first flower bud initiation and number of days taken to first flower opening of gerbera.

Treatment		Number of days taken to first flower bud initiation (Days)	Number of days taken to first flower opening (Days)
T_1	100% RDF (Control)	57.33^{e}	76.80^{e}
T_2	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L	52.00^{b}	74.06^{cd}
T_3	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L	54.73^{d}	74.40^{d}
T_4	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L	49.73^{b}	71.13^{b}
T_5	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L	53.60^{c}	73.86^{bc}
T_6	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L	45.73^{a}	65.20^{a}
T_7	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L	53.40^{bc}	72.40^{bc}
	S.E(m) ±	0.46	0.62
	C.D @ 5%	1.41	1.89

days) and maximum number of days for first flower opening were recorded in T_1 (control) with (76.80 days). Khosa *et al*. (11) reported that minimum number of days taken for flower opening by foliar application of micronutrients.

It is vivid from Table 2 and (Fig 1, 2) that different foliar application of nano urea, nano DAP and micronutrients was significantly affected the flower diameter and flower stalk length of Gerbera. Among all treatments, maximum flower diameter was recorded in T_6 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Liquid micronutrients @ 2.5 ml/L (Fortnight intervals from 30 days onwards up to 150 days)] with (11.93 cm) and it was on par with T_4 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Micronutrients (Solid form) @ 5 g/L (Fortnight intervals from 30 days onwards up to 150 days)] recorded with (11.66 cm) and minimum flower diameter (10.96 cm) were recorded in the treatment T_1 (control). Due to nitrogen level might have

Table 2: Effect of nano urea, nano DAP and micronutrients on flower diameter at complete opening and flower stalk length.

Treatment		Flower diameter at complete opening (cm)	Flower stalk length (cm)
T_1	100% RDF (Control)	10.96^{d}	49.84^{e}
T_2	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L	11.32^{c}	53.41^{c}
T_3	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L	11.28^{cd}	53.06^{de}
T_4	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L	11.66^{ab}	57.94^{b}
T_5	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml /L + Micronutrients (Solid form) @ 5 g/L	11.44^{bc}	53.32^{cd}
T_6	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L	11.93^{a}	64.17^{a}
T_7	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml /L + Liquid micronutrients @ 2.5 ml/L	11.50^{bc}	53.52^{c}
	S.E(m) ±	0.11	0.43
	C.D @ 5%	0.35	1.31

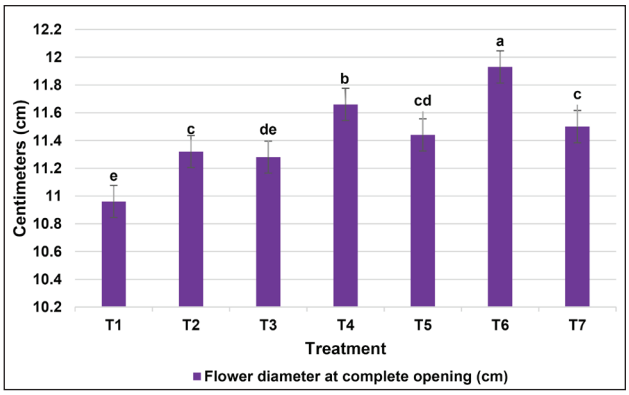

Fig. 1. Effect of nano urea, nano DAP and micronutrients on flower diameter at complete opening.

T_1-100% RDF (Control)
T_2-75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L
T_3-50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L
T_4-75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3ml/L + Micronutrients (Solid form) @ 5 g/L
T_5-50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L
T_6-75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L
T_7- 50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L

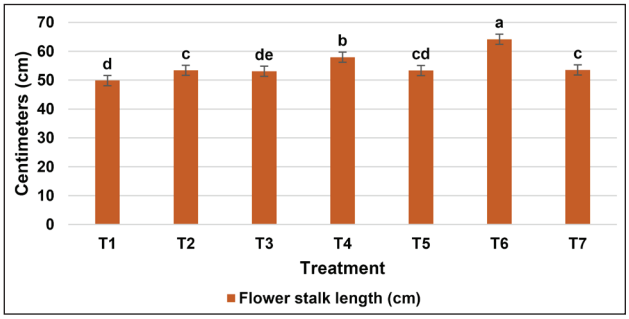

Fig. 2. Effect of nano urea, nano DAP and micronutrients on flower stalk length.

T_1-100% RDF (Control)
T_2-75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L
T_3-50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L
T_4-75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L
T_5-50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L
T_6-75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L
T_7- 50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L

accelerated photosynthetic activity by increasing size, thereby providing flowers with more photosynthates, which might have resulted in increased cell division and cell expansion thereby increased flower size in terms of flower diameter. The present findings are consistent with those reported by Devi *et al.* (5) and Venkatesh *et al.* (19) in African marigold, who observed significant improvements in floral traits following nutrient application. Similar results were also documented by Kashif *et al.* (10) in dahlia, where foliar application of micronutrients significantly enhanced flower diameter. These observations suggest that improved nutrient availability and uptake may contribute to enhanced floral development and flower quality.

The flower stalk length is differed significantly among all the treatments. The maximum flower stalk length was recorded in T_6 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Liquid micronutrients @ 2.5 ml/L (Fortnight intervals from 30 days onwards up to 150 days)] with (64.17 cm) followed by T_4 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Micronutrients (Solid form) @ 5 g/L (Fortnight intervals from 30 days onwards up to 150 days)] recorded with (57.94 cm). However, minimum flower stalk length (49.84 cm) was recorded in T_1 (control). The data recorded on flower stalk length indicated that maximum value was noted in T_6 was due to same treatment recorded maximum flower diameter and flower stalk diameter rather than other treatments. These findings are in consonance with the report of Mounika *et al.* (12) in gerbera and they found that foliar application of micronutrients had an erratic effect on flower stalk length.

The data recorded on flower yield per plant as influenced by foliar application of nano urea, nano DAP and micronutrients is presented in the Table 3 and depicted in Fig 3. The significant difference was observed for flower yield per plant in the month of March, April, May and June in all treatments. Maximum flower yield per plant in the month of March was recorded in T_6 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Liquid micronutrients @ 2.5 ml/L (Fortnight intervals from 30 days onwards up to 150 days)] with (1.20) and it was on par with T_4 (1.13) and minimum flower yield per plant was recorded in T_3 and T_5 (0.93) (0.93) respectively. There was no flower yield was noticed in treatment T_1 (control) in the month of March. Among all treatments, maximum flower yield per plant was noticed in T_6 with (1.53) and it was at par with T_4 (1.46). The minimum flower yield per plant was found in T_1 (control) with (0.93) in the month of April. Maximum flower yield per plant in the month of May was recorded in T_6 with (2.00) and it was on par with T_4 (1.80) and minimum flower yield per plant was noticed in T_1 (control) (1.13) in the month of May. Among all treatments, maximum flower yield per plant in the month of June was recorded in

Table 3: Effect of nano urea, nano DAP and micronutrients on flower yield per plant per month of gerbera.

Treatment		Flower yield per plant (No.)			
		March	April	May	June
T_1	100% RDF (Control)	0.00^{c}	0.93^{c}	1.13^{c}	1.40^{d}
T_2	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L	1.00^{ab}	1.20^{b}	1.33^{bc}	1.6^{cd}
T_3	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L	0.93^{b}	1.06^{bc}	1.26^{bc}	1.53^{cd}
T_4	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L	1.13^{ab}	1.46^{a}	1.80^{a}	2.06^{b}
T_5	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L	0.93^{b}	1.06^{bc}	1.40^{b}	1.66^{cd}
T_6	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L	1.20^{a}	1.53^{a}	2.00^{a}	2.40^{a}
T_7	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml /L + Liquid micronutrients @ 2.5 ml/L	1.00^{ab}	1.20^{bc}	1.46^{b}	1.73^{c}
	S.E(m) ±	0.07	0.05	0.06	0.09
	C.D @ 5%	0.22	0.17	0.20	0.27

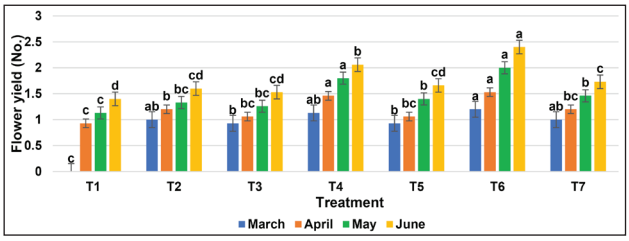

Fig. 3. Effect of nano urea, nano DAP, and micronutrients on flower yield per plant per month.

T_1-100% RDF (Control)
T_2-75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L
T_3-50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L
T_4-75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L
T_5-50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L
T_6-75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L
T_7- 50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L

T_6 with (2.40). The treatment T_4 recorded with (2.06). However, minimum flower yield per plant was found in T_1 (control) with (1.40) in the month of June. The comparison over the months with regards to flower yield per plant was maximum in T_6 and in the month of June might be due to greater number of suckers, maximum leaf area, more leaves per plant and plant spread were noticed in this treatment which led to the synthesis and accumulation of most photosynthates, leading to creation of more flowers with larger sizes are produced.

The data about flower stalk diameter and total flower yield per plant of gerbera from establishment to 150 days after planting as affected by foliar application of nano urea, nano DAP and micronutrients is depicted in the Table 4. When compared to control, the treatments showed marginal differences pertaining to flower stalk diameter and among all, the maximum flower stalk diameter was recorded in T_6 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Liquid micronutrients @ 2.5 ml/L (Fortnight intervals from 30 days onwards up to 150 days)] with (8.30 mm) and whereas, minimum flower stalk diameter was noted in T_1 (control) with (6.96 mm). According to Biswal *et al.* (4), variation in flower stalk diameter may be attributed to differences in the accumulation and translocation of assimilates within the flower stalk tissues. Palanisamy *et al.* (13) reported that the combined application of NaO_3^- and NH_4^+ enhanced nutrient absorption, particularly nitrogen uptake, which consequently promoted greater flower stalk girth. The increase in stalk diameter observed in the present study may therefore be associated with improved nutrient availability and enhanced metabolic activity supporting structural development. Similar findings have also been reported by Gowtham and Karuppaiah (7) in Crossandra, Jena *et al.* (8) in Gerbera, and Patel *et al.* (14) in Rose.

Among all treatments, maximum flower yield per plant was recorded in T_6 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Liquid micronutrients @ 2.5 ml/L (Fortnight intervals from 30 days onwards up to 150 days)] with (7.13) and T_4 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @

3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Micronutrients (Solid form) @ 5 g/L (Fortnight intervals from 30 days onwards up to 150 days)] recorded with (6.46). However, the minimum total flower yield per plant was noticed in T_1 (control) with (3.46). It was due to fact that the crop plants in these treatments experienced good vegetative growth right from early stages of growth period due to higher absorption of nitrogen which might have resulted in higher photosynthetic activity and higher number of flowers per plant.

The data depicted on longevity of the flowers on the plant and fresh weight of the flowers as influenced by foliar application of nano urea, nano DAP and micronutrients (Table 5). The foliar application of nano urea, nano DAP and micronutrients was significantly affected the longevity of flower on the plant in all treatments, the maximum number of days of longevity on the plant was noticed in T_6 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Liquid micronutrients @ 2.5 ml/L (Fortnight

Table 4: Effect of nano urea, nano DAP and micronutrients on flower stalk diameter and total flower yield per plant from establishment to 150 days after planting of gerbera.

Treatment		Flower stalk diameter (mm)	Total flower yield per plant from establishment to 150 DAP
T_1	100% RDF (Control)	6.96^{e}	3.46^{e}
T_2	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L	7.56^{cd}	5.13^{cd}
T_3	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L	7.07^{d}	4.80^{de}
T_4	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L	7.88^{b}	6.46^{b}
T_5	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L	7.56^{cd}	5.06^{d}
T_6	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L	8.30^{a}	7.13^{a}
T_7	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L	7.65^{c}	5.33^{c}
	S.E(m) ±	0.04	0.21
	C.D @ 5%	0.13	0.65

Table 5: Effect of nano urea, nano DAP and micronutrients on fresh weight of the flower and longevity of the flowers on plant of gerbera.

Treatment		Fresh weight of the flower (g)	Longevity of the flowers on plant (Days)
T_1	100% RDF (Control)	25.50^{e}	11.60^{e}
T_2	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L	28.54^{cd}	13.00^{c}
T_3	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L	27.48^{d}	11.80^{de}
T_4	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L	31.78^{bc}	14.13^{b}
T_5	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L	29.63^{c}	12.46^{cde}
T_6	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L	34.5^{a}	15.53^{a}
T_7	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L	32.39^{b}	12.66^{cd}
	S.E(m) ±	0.43	0.34
	C.D @ 5%	1.31	1.03

intervals from 30 days onwards up to 150 days)] with (15.53 days) and followed by T_4 with (14.13 days). However, the minimum value for longevity of flowers on plant (11.60 days) was recorded in T_1 (control).

The data pertaining to fresh weight of flower as influenced by foliar application of nano urea, nano DAP and micronutrients. Among all treatments the maximum flower weight was recorded in T_6 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Liquid micronutrients @ 2.5 ml/L (Fortnight intervals from 30 days onwards up to 150 days)] with (34.5 g). The treatment T_7 [50% N + 50% P_2O_5 + 100% K_2O + nano DAP @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Liquid micronutrients @ 2.5 ml/L (Fortnight intervals from 30 days onwards up to 150 days)] recorded with (32.39 g) and it was on par with T_4 (31.78 g) and minimum yield per plant was recorded in T_1 (control) (25.50 g). The increased flower weight and diameter observed in the present study may be attributed to the application of micronutrient mixtures, which likely enhanced cell wall permeability, improved water translocation, and stimulated the synthesis and accumulation of photosynthates. These physiological responses may have promoted cell expansion and the development of larger ray florets, resulting in improved floral attributes. Similar observations were reported by Vanlalruati *et al.* (18), who highlighted the role of micronutrients in enhancing flower size and quality. The present findings are also in agreement with those of Thakur *et al.* (17) and Swetha *et al.* (16) in gaillardia.

Scape bending curvature and vase life of gerbera flowers in distilled water as influenced by foliar application of nano urea, nano DAP and micronutrients on Gerbera is presented in Tables 6 and Fig 4. Significant difference was recorded in respect of scape bending curvature due to foliar application of nano particles as well as micronutrients. Among all treatments minimum scape bending curvature was

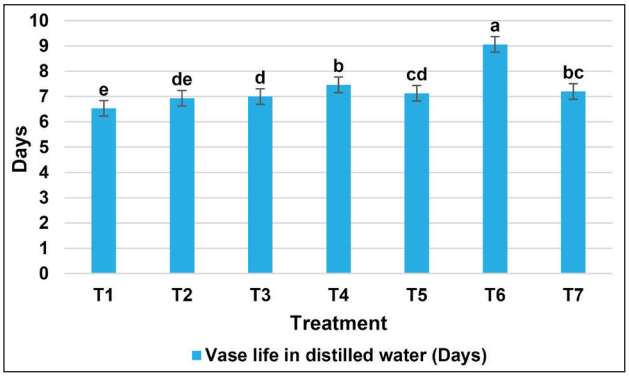

Fig. 4. Effect of nano urea, nano DAP and micronutrients on vase life in distilled water.

T_1-100% RDF (Control)
T_2-75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L
T_3-50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L
T_4-75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L
T_5-50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L
T_6-75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 m/L + Liquid micronutrients @ 2.5 ml/L
T_7- 50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L

Table 6: Effect of nano urea, nano DAP and micronutrients on vase life in distilled water and scape bending curvature.

Treatment		Vase life in distilled water (Days)	Scape bending curvature (°)
T_1	100% RDF (Control)	6.53^{e}	37.62^{e}
T_2	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L	6.93^{de}	30.99^{c}
T_3	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L	7.00^{d}	31.97^{d}
T_4	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L	7.46^{b}	13.72^{b}
T_5	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Micronutrients (Solid form) @ 5 g/L	7.13^{cd}	31.83^{cd}
T_6	75% N + 75% P_2O_5 + 100% K_2O + Nano urea @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L	9.06^{a}	11.42^{a}
T_7	50% N + 50% P_2O_5 + 100% K_2O + Nano DAP @ 3 ml/L + Liquid micronutrients @ 2.5 ml/L	7.20^{bc}	29.30^{c}
	S.E(m) ±	0.26	0.44
	C.D @ 5%	0.77	1.34

recorded in T_6 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Liquid micronutrients @ 2.5 ml/L (Fortnight intervals from 30 days onwards up to 150 days)] with (11.42°) followed by the T_4 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Micronutrients (Solid form) @ 5 g/L (Fortnight intervals from 30 days onwards up to 150 days)] recorded with (13.72°) and maximum scape bending were in T_1 (control) with (37.62°).

The data concerning to vase life of cut Gerbera was influenced by foliar application of nano particles along with basal nutrients and found significant results in different treatments (Plate 1). The T_6 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Liquid micronutrients @ 2.5 ml/L (Fortnight intervals from 30 days onwards up to 150 days)] recorded with (9.06 days) followed by T_4 [75% N + 75% P_2O_5 + 100% K_2O + nano urea @ 3 ml/L (Fortnight intervals from 30 days onwards up to 150 days) + Micronutrients (Solid form) @ 5 g/L (Fortnight intervals from 30 days onwards up to 150 days)] recorded with (7.46 days) and minimum vase life were recorded in T_1 (control) with (6.53 days). The extended vase life observed in the present study may be attributed to the role of micronutrients such as zinc, iron, and magnesium in activating several enzymatic systems and facilitating chlorophyll biosynthesis along with other essential physiological and metabolic processes. These improvements likely contributed to enhanced postharvest quality, delayed senescence, and prolonged floral longevity. Similar observations were reported by Mounika *et al.* (12), who emphasized the positive influence of micronutrients on vase life enhancement. The present results are also in agreement with the findings of Wilson *et al.* (20).

The application of nano fertilizers and liquid micronutrients significantly improved flowering and yield attributes of gerbera under shade net conditions. Enhanced nutrient availability and efficient uptake promoted better plant growth, increased flower production, and improved floral quality parameters. Among the treatments, optimized nutrient combinations exhibited superior performance in terms of flower yield and overall plant productivity. Therefore, the integration of nano fertilizers with liquid micronutrients can be considered an effective and sustainable nutrient management strategy for commercial gerbera cultivation under protected conditions.

Plate 1: Overall view of the vase life of gerbera.

AUTHOR'S CONTRIBUTION

Conceptualization of research (SKS & BKK); Designing of the experiments (BKK, LKV & RKV); Contribution of experimental materials (BKK & RKV); Execution of field/lab experiments and data collection (SKS); Analysis of data and interpretation (SKS, BKK & KSP); Preparation of the manuscript (KSK & KBB).

DECLARATION

The authors should declare that they do not have any conflict of interest.

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