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Effect of Nutrient Deficiencies on Growth and Leaf Tissue Concentration of Gerbera var. Savannah

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ABSTRACT

Keywords

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Present investigation was conducted in AICRIP on Flower crops, Rajendranagar, Rangareddy district of Telangana state to study the influence of different nutrient deficiencies on growth and leaf tissue concentrations of Gerbera var. Savannah through solution culture. Plants were treated with complete Hoagland solution and deficiencies were incorporated with a complete nutrient formula minus one of the nutrients. Plants treated with nitrogen deficiency solution showed significant reduction in growth followed by P, K, Ca, Fe, and Mg. Root length of phosphorous deficient plants and shoot/root ratio of iron deficient plants were increased. Visual deficiency symptoms were expressed except for manganese deficiency during the period of study (60 DAT). Leaf analysis at 60 DAT revealed that in deficiency situation, content of individual mineral element was significantly reduced.

Introduction

Gerbera (*Gerbera jamesonii* L.) belonging to Asteraceace is one among the top ten cut flowers in the world, indigenous to South Africa and Asia as a perennial herb. In India, they are distributed in the temperate Himalayas from Kashmir to Nepal at altitudes from 1,300 to 3,200 m. among cut flowers as per Global trends in floriculture, it occupies fourth place (Sujatha *et al.*, 2002). In India, it is cultivated in an area of 900 ha with a production of 4000 MT loose flowers and 23.84 lakhs cut flowers with Assam as state

under highest area of cultivation (600 ha) and Telangana being the major cut flower producer (6.01 lakhs) (Anon., 2014-15). In Telangana it is cultivated in an area of 70 ha under Naturally ventilated polyhouses.

Gerberas, for commercial production, are considered as moderate feeders. This moderate level of fertility produces a plant with a proportional leaf area to flower ratio. Any raise or decrease in nutrient supply results in unusual growth and yield loss thereby stressing the need of balanced nutrition. Information on deficiency symptoms of

nutrients would aid the grower in problem identification. Qualitative techniques, as visual diagnosis are very useful to detect an individual problem, but when visual symptom shows up, some reduction in yield has already been caused. For this reason quantitative technique such as foliar analysis is preferred. The critical leaf tissue concentration also highly significant to determine nutritional status of plants. Balancing the needs of plant and periodic monitoring will help in assured implementation of nutritional requirements. Therefore, the standards for leaf tissue nutrient concentrations are important to determine nutritional status of plants and take up corrective measures. Hence this experiment is aimed to elucidate the influence of different nutrient deficiencies on growth and leaf tissue concentrations of Gerbera.

Materials and Methods

Tissue culture plants of Gerbera variety Savannah grown prior to treatment in peat based compost were used in the present investigation. Plants of uniform size with 3-4 leaf stage were selected. Twelve treatments (Fig. 1) viz. Complete Hoagland solution and complete minus N, P, K, Ca, Mg, S, Mn, B, Fe, Zn, Cu were used to incorporate deficiencies (Table 1) (Hoagland and Arnon, 1950). The nutrient treatments were arranged in a completely randomized design with 12 plants each treatment and daily provided aeration using Aspirator (Fig. 2). Nutrient solutions were replaced at weekly intervals and volume is maintained by adding distilled water. Observations regarding leaf area, root length and shoot/root ratio were recorded at end of the experiment *i.e.*, 60 DAT. Leaves were collected at end of the experiment and analyzed for content of Nitrogen by employing KELPLUS digestion and distillation system (Subbaiah and Asija, 1956), Phosphorous by Vanado-molybdo phosphoric yellow colour method (Jackson, 1973), Potassium by Flame photometer (Tandon,

1993), Calcium and Magnesium by Versenate titration method (Tandon, 1993), Sulphur by Turbidity method (Chesnin and Yien, 1950), Boron by hot water extraction method (Berger and Troug, 1939), Mn, Zn, Fe, Cu by feeding extract to atomic absorption spectrophotometer (Tandon, 1993). The data was analyzed by using software OPSTAT in CRD.

Results and Discussion

Deficiency of macronutrients

Nitrogen

Leaf tissue N concentration of Gerbera plants treated with complete nutrient solution was recorded 3.12 per cent, whereas for plants treated with N deficient nutrient solution has recorded 1.1 per cent (Table 2). For pot gerbera, leaf tissue N concentration was reported to be 2.7-4.1 per cent (Dole and Wilkins, 2005) and in cut gerbera was 1.5-3.5 per cent, under N deficiency conditions, threshold level of N in cut Gerbera was reported to be 1.2 per cent (Ocampo, 2001). There was significant reduction in the growth as compared to complete treatment (control) (Table 3). Decrease in values was recorded for plant height (11.40 cm, 25.50 cm), leaf area (20.87cm², 44.34 cm²), root length (13.65 cm, 28.97 cm) and shoot/root ratio (2.12, 2.88). Since N is fourth most major element required for plant growth and development it's deficiency resulted in poor growth. Sulphur content was recorded higher (0.67%) in N deficient leaves (Table 2) due to antagonism between N and S which has resulted in accumulation of more non-protein S compounds in vegetative tissues (Fageria, 2001).

Phosphorous

Leaf tissue P concentration of Gerbera plants treated with complete nutrient solution was recorded 0.6 per cent, whereas for plants

treated with P deficient nutrient solution has recorded 0.11 percent (Table 2). For pot gerbera, leaf tissue P concentration was reported to be 0.3-0.7 per cent (Dole and Wilkins, 2005) and in cut gerbera was 0.2-0.5 per cent, under P deficiency conditions, threshold level of P in cut Gerbera was reported to be 0.15 per cent (Ocampo, 2001). There was significant reduction in the growth as compared to control treatment (Table 3). Decrease in values was recorded for plant height (14.50 cm, 25.50 cm) and leaf area (22.23 cm², 44.34 cm²). Whereas, root length (33.20 cm, 28.97 cm) and shoot/root ratio (3.12, 2.88) was recorded higher for P deficient treatment compared to complete nutrient treatment. The increase in shoot/root ratio in phosphorous deficient plants was due to increase in root length due to elongation of tap root because of diversion of assimilates from shoot to root in search of phosphorous (Fredeen *et al.*, 1989).

Potassium

Leaf tissue K concentration of Gerbera plants treated with complete nutrient solution was recorded 2.97 per cent, whereas for plants treated with K deficient nutrient solution has recorded 1.46 percent (Table 2). For pot gerbera leaf tissue K concentration was reported to be 3.1-3.9 per cent (Dole and Wilkins, 2005) and in cut gerbera was 2.5-4.5 per cent, under K deficiency conditions, threshold level of K in cut Gerbera was reported to be 2 per cent (Ocampo, 2001). There was significant reduction in the growth as compared to control treatment except for shoot/root ratio which was recorded higher (3.45, 2.88) (Table 3). Decrease in values was recorded for plant height (16.40 cm, 25.50 cm), leaf area (28.45 cm², 44.34 cm²) and root length (22.84, 28.97). There was an interaction recorded between K, N and K, Mg due to antagonism between them which resulted in increase in N and Mg content (3.45 % and

0.79%) (Table 2). The increase in N was due to the competition of K with N (NH₄) for uptake (Chang *et al.*, 2001). Both Mg and K ions are quite similar in size and charge and hence, exchange site cannot distinguish the difference between the ions (Ujwala, 2011), thereby there was increase in Mg content in K deficient leaves.

Calcium

Leaf tissue Ca concentration for Gerbera plants treated with complete nutrient solution was recorded 1.43 per cent, whereas for plants treated with Ca deficient nutrient solution has recorded 0.33 percent (Table 2). For pot gerbera leaf tissue Ca concentration was reported to be 3.1-3.9 per cent (Dole and Wilkins, 2005) and in cut gerbera was 1.0-3.5 per cent, under Ca deficiency conditions, threshold level of Ca in cut Gerbera was reported to be 0.7 per cent (Ocampo, 2001). There was significant reduction in the growth as compared to control (Table 3). Decrease in values was recorded for plant height (15.63 cm, 25.50 cm), leaf area (25.55cm², 44.34 cm²), root length (19.38 cm, 28.97 cm) and shoot/root ratio (2.75, 2.88). Boron concentration was recorded higher (71.75 ppm) in Ca deficient leaves (Table 2) due to antagonism between Ca and B due to localization of Ca in cell wall which had decreased cell wall boron permeability (Turan *et al.*, 2009).

Magnesium

Leaf tissue Mg concentration for Gerbera plants treated with complete nutrient solution was recorded 0.6 per cent, whereas for plants treated with Mg deficient nutrient solution has recorded 0.13 percent (Table 2). For pot gerbera leaf tissue Mg concentration was reported to be 0.24-0.63 per cent and in cut gerbera was 0.2-0.7 per cent, under Mg deficiency conditions, threshold level of Mg in

cut Gerbera was reported to be 0.15 per cent (Ocampo, 2001). There was significant reduction in the growth as compared to control treatment except for shoot/root ratio (3.26, 2.88) which recorded higher (Table 3). Decrease in values was recorded for plant height (17.87 cm, 25.50 cm), leaf area (31.78cm², 44.34 cm²) and root length (19.75 cm, 28.97 cm).

There was an antagonistic interaction recorded among Mg and K, Ca, Mn which resulted in increased concentrations of K (3.51%), Ca (2.09 %) and Mn (109.45 ppm) in leaves (Table 2). Both Mg and K ions are quite similar in size and charge and hence, exchange site cannot distinguish the difference between the ions and binding site of K is much stronger than Mg and it easily out-compete Mg *i.e.*, more K was absorbed at exchange sites (Ujwala, 2011). High rhizosphere concentrations of calcium, relative to magnesium are inhibitory to the absorption of magnesium and vice versa (Merhaut, 2006). Manganese, as a divalent cation, can compete with magnesium for binding sites on soil particles as well as biological membranes within plants (Merhaut, 2006).

Sulphur

Leaf tissue S concentration for Gerbera plants treated with complete nutrient solution was recorded 0.38 per cent, whereas for plants treated with S deficient nutrient solution has recorded 0.08 per cent (Table 2).

For cut gerbera leaf tissue S concentration was 0.25-0.5 per cent and under S deficiency conditions, threshold level of S in cut Gerbera was reported to be 0.16 per cent (Ocampo, 2001). There was significant reduction in the growth as compared to control treatment except for shoot/root ratio (2.98, 2.88) which recorded higher (Table 3). Decrease in values was recorded for plant height (18.77 cm, 25.50

cm), leaf area (32.38 cm², 44.34 cm²) and root length (19.58 cm, 28.97 cm).

Deficiency of Micronutrients

Manganese

Leaf tissue Mn concentration for Gerbera plants treated with complete nutrient solution was recorded 72.93 ppm, whereas for plants treated with Mn deficient nutrient solution has recorded 28.4 ppm (Table 2). For pot gerbera leaf tissue Mn concentration was reported to be 30-260 ppm (Dole and Wilkins, 2005) and in cut gerbera was 40-250 ppm, under Mn deficiency conditions, threshold level of Mn in cut Gerbera was reported to be 30 ppm (Ocampo, 2001). There was significant reduction in the growth as compared to control treatment (Table 3).

Decrease in values was recorded for plant height (22.15 cm, 25.50 cm), leaf area (37.78 cm², 44.34 cm²), root length (26.41 cm, 27.93 cm) and shoot/root ratio (2.66, 2.88).

Boron

Leaf tissue B concentration for Gerbera plants treated with complete nutrient solution was recorded 44.50 ppm, whereas for plants treated with B deficient nutrient solution has recorded 14.6 ppm (Table 2). For pot gerbera leaf tissue B concentration was reported to be 19-50 ppm (Dole and Wilkins, 2005) and in cut gerbera was 20-60 ppm, under B deficiency conditions, threshold level of B in cut Gerbera was reported to be 15 ppm (Ocampo, 2001). There was significant reduction in the growth as compared to control treatment (Table 3).

Decrease in values was recorded for plant height (20.55 cm, 23.50 cm), leaf area (33.57 cm², 42.34 cm²), root length (25.85 cm, 27.93 cm) and shoot/root ratio (2.76, 2.88).

Iron

Leaf tissue Fe concentration for Gerbera plants treated with complete nutrient solution was recorded 169.55 ppm, whereas for plants treated with Fe deficient nutrient solution has recorded 14.6 ppm (Table 2). For pot gerbera leaf tissue Fe concentration was reported to be 60-130 ppm (Dole and Wilkins, 2005) and in cut gerbera was 50-200 ppm, under Fe deficiency conditions, threshold level of Fe in cut Gerbera was reported to be 40 ppm (Ocampo, 2001). There was significant reduction in the growth as compared to control treatment except for shoot/root ratio which recorded higher (3.11, 2.88) (Table 2). Decrease in values was recorded for plant height (13.41 cm, 25.50 cm), leaf area (33.60 cm², 44.34 cm²) and root length (16.40 cm, 28.97 cm).

There was an interaction recorded between Fe, Cu and Fe, Zn due to antagonism between them which resulted in increase in Cu and Zn content (28.5 ppm and 79.25 ppm) (Table 2). Cu and Fe have similar affinity to different enzymatic systems (Cohu and Pilon, 2007). Hence, under Fe deficiency, a metabolic shift had occurred which had enhanced the reduction capacity resulting in a greater uptake of Cu (Gama *et al.*, 2015), whereas, Zn and Mn interfere with Fe utilization in the leaves for chlorophyll synthesis (Fageria, 2001).

Zinc

Leaf tissue Zn concentration for Gerbera plants treated with complete nutrient solution was recorded 57.53 ppm, whereas for plants treated with Zn deficient nutrient solution has recorded 12.4 ppm (Table 2). For pot gerbera leaf tissue Zn concentration was reported to be 19-80 ppm (Dole and Wilkins, 2005) and in cut gerbera was 25-100 ppm, under Zn deficiency conditions, threshold level of Zn in cut Gerbera was reported to be 20 ppm

(Ocampo, 2001). There was significant reduction in the growth as compared to control treatment (Table 3). Decrease in values was recorded for plant height (20.47 cm, 25.50 cm), leaf area (36.39 cm², 44.34 cm²), root length (26.75 cm, 28.97 cm) and shoot/root ratio (2.45, 2.88).

Phosphorous content in Zn deficient leaves was recorded more (0.77%) (Table 2) due to antagonisms between them as zinc deficiency enhanced the uptake rate of phosphorus by the roots and translocated to the shoots which can be part of an expression of higher passive permeability of the plasma membranes of root cells or impaired control of xylem loading (Storey, 2006).

Copper

Leaf tissue Cu concentration for Gerbera plants treated with complete nutrient solution was recorded 13.3 ppm, whereas for plants treated with Fe deficient nutrient solution has recorded 3.21 ppm (Table 2). For pot gerbera leaf tissue Cu concentration was reported to be 2-10 ppm (Dole and Wilkins, 2005) and in cut gerbera was 6-20 ppm, under Cu deficiency conditions, threshold level of Cu in cut Gerbera was reported to be 4 ppm (Ocampo, 2001). There was significant reduction in the growth as compared to control treatment except for shoot/root ratio (3.11, 2.88) which recorded higher (Table 3). Decrease in values was recorded for plant height (17.25 cm, 25.50 cm), leaf area (35.65 cm², 44.34 cm²) and root length (23.59 cm, 28.97 cm).

Iron content in Cu deficient leaves was recorded more (256.4 ppm) (Table 2) due to antagonism between them as Cu in excess interferes with plant's capacity to absorb and/or translocate other nutrients (Fe) inhibiting root elongation and adversely affecting the permeability of the root cell membrane (Fageria, 2001).

Table.1 Composition of nutrient solutions for various treatments (ml.l⁻¹)

Treatment	Composition of nutrients (ml/lit)
T1 (complete)	KNO ₃ @ 6ml + Ca(NO ₃) ₂ .4H ₂ O @ 4ml + NH ₄ H ₂ PO ₄ @ 2ml + MgSO ₄ .7H ₂ O @ 1ml + Fe-EDTA @ 1ml + Micronutrients @ 1ml
T2 (-N)	MgSO ₄ .7H ₂ O @ 1ml+ Fe-EDTA @ 1ml + Micronutrients @ 1ml + CaCl ₂ @ 4ml+ KCl @ 6ml + NaH ₂ PO ₄ .2H ₂ O @ 2ml
T3 (-P)	KNO ₃ @ 6ml + Ca(NO ₃) ₂ .4H ₂ O @ 4ml + MgSO ₄ .7H ₂ O @ 1ml + Fe-EDTA @ 1ml+ Micronutrients @ 1ml + NH ₄ Cl @ 2ml
T4 (-K)	Ca(NO ₃) ₂ .4H ₂ O @ 4ml + NH ₄ H ₂ PO ₄ @ 2ml+ MgSO ₄ .7H ₂ O @ 1ml + Fe-EDTA @ 1ml + Micronutrients @ 1ml + NaNO ₃ @ 6ml
T5 (-Ca)	KNO ₃ @ 6ml + NH ₄ H ₂ PO ₄ @ 2ml + MgSO ₄ .7H ₂ O @ 1ml + Fe-EDTA @ 1ml + Micronutrients @ 1ml + NaNO ₃ @ 8ml
T6 (-Mg)	KNO ₃ @ 6ml + Ca(NO ₃) ₂ .4H ₂ O @ 4ml + NH ₄ H ₂ PO ₄ @ 2ml + Fe-EDTA @ 1ml + Micronutrients @ 1ml + Na ₂ SO ₄ @ 1ml
T7 (-S)	KNO ₃ @ 6ml + Ca(NO ₃) ₂ .4H ₂ O @ 4ml + NH ₄ H ₂ PO ₄ @ 2ml+ Fe-EDTA @ 1ml + Micronutrients @ 1ml + MgCl ₂ .6H ₂ O @ 1ml
T8 (-Mn)	KNO ₃ @ 6ml + Ca(NO ₃) ₂ .4H ₂ O @ 4ml + NH ₄ H ₂ PO ₄ @ 2ml + MgSO ₄ .7H ₂ O @ 1ml +Fe-EDTA @ 1ml + Micronutrients @ 1ml –Mn
T9 (-B)	KNO ₃ @ 6ml + Ca(NO ₃) ₂ .4H ₂ O @ 4ml + NH ₄ H ₂ PO ₄ @ 2ml + MgSO ₄ .7H ₂ O @ 1ml + Fe-EDTA @ 1ml + Micronutrients @ 1ml- B
T10 (-Fe)	KNO ₃ @ 6ml + Ca(NO ₃) ₂ .4H ₂ O @ 4ml + NH ₄ H ₂ PO ₄ @ 2ml + MgSO ₄ .7H ₂ O @ 1ml + Micronutrients @ 1ml
T11 (-Zn)	KNO ₃ @ 6ml + Ca(NO ₃) ₂ .4H ₂ O @ 4ml + NH ₄ H ₂ PO ₄ @ 2ml + MgSO ₄ .7H ₂ O @ 1ml + Fe-EDTA @ 1ml + Micronutrients @ 1ml – Zn
T12 (-Cu)	KNO ₃ @ 6ml + Ca(NO ₃) ₂ .4H ₂ O @ 4ml + NH ₄ H ₂ PO ₄ @ 2ml + MgSO ₄ .7H ₂ O @ 1ml + Fe-EDTA @ 1ml + Micronutrients @ 1ml – Cu

Table.2 Leaf tissue concentrations of macro (%) and micro nutrients (ppm) and their interaction levels in leaf tissues of cut Gerbera a var. Savannah

Leaf tissue concentration of cut Gerbera var. Savannah.											
Treatments	N	P	K	Ca	Mg	S	Mn	B	Fe	Zn	Cu
T₁(Complete)	3.12	0.61	2.97	1.43	0.60	0.38	72.93	44.50	169.55	57.53	13.30
T₂ (-N)	1.10	0.47	3.20	1.84	0.58	0.67	55.67	59.25	205.5	73.35	11.35
T₃ (-P)	2.75	0.11	3.38	1.59	0.53	0.45	60.70	41.38	210.25	70.30	17.16
T₄(-K)	3.45	0.65	1.46	1.78	0.79	0.38	94.63	60.50	45.00	63.80	18.70
T₅ (-Ca)	2.35	0.39	3.29	0.33	0.65	0.34	55.61	71.75	248.50	65.25	19.14
T₆ (-Mg)	2.68	0.71	3.51	2.09	0.13	0.49	109.45	22.80	121.40	71.55	12.15
T₇ (-S)	2.62	0.64	3.43	1.55	0.72	0.08	54.85	45.75	135.55	41.15	16.40
T₈ (-Mn)	2.63	0.31	3.44	1.44	0.63	0.42	28.40	33.85	225.20	53.50	19.40
T₉ (-B)	2.60	0.41	2.67	1.95	0.60	0.43	55.03	14.60	159.80	68.05	18.10
T₁₀ (-Fe)	2.56	0.35	2.71	1.15	0.63	0.41	51.24	68.50	36.58	79.25	28.50
T₁₁ (-Zn)	2.75	0.77	3.05	1.5	0.51	0.55	55.52	36.35	197.50	12.40	25.20
T₁₂ (-Cu)	2.60	0.70	3.22	1.16	0.65	0.525	52.05	46.61	256.40	67.15	3.21
S Em ±	0.032	0.008	0.008	0.009	0.009	0.004	0.284	0.289	0.446	0.224	0.206
C D (p=0.05)	0.099	0.025	0.026	0.028	0.029	0.011	0.885	0.901	1.39	0.699	0.641

Table.3 Effect of different nutrient deficiencies on growth parameters of Gerbera at 60 DAT

Treatments	Plant height (cm)	Leaf area (cm ²)	Root length (cm)	Shoot/Root ratio
T₁(Complete)	25.50	44.34	28.97	2.88
T₂ (-N)	11.40	20.87	13.65	2.12
T₃ (-P)	14.50	22.23	33.20	3.12
T₄(-K)	16.40	28.45	22.84	3.45
T₅ (-Ca)	15.63	25.55	19.38	2.75
T₆ (-Mg)	17.87	31.78	19.75	3.26
T₇ (-S)	18.77	32.38	19.58	2.98
T₈ (-Mn)	22.15	37.78	26.41	2.66
T₉ (-B)	21.55	34.57	22.43	2.86
T₁₀ (-Fe)	13.41	33.60	16.40	3.39
T₁₁ (-Zn)	20.47	36.39	26.75	2.45
T₁₂ (-Cu)	17.25	35.65	23.59	3.11
S Em ±	0.142	0.126	0.172	0.09
C D (p= 0.05)	0.416	0.369	0.504	0.265

Fig.1 Gerbera plants grown in complete and deficiency nutrient solutions

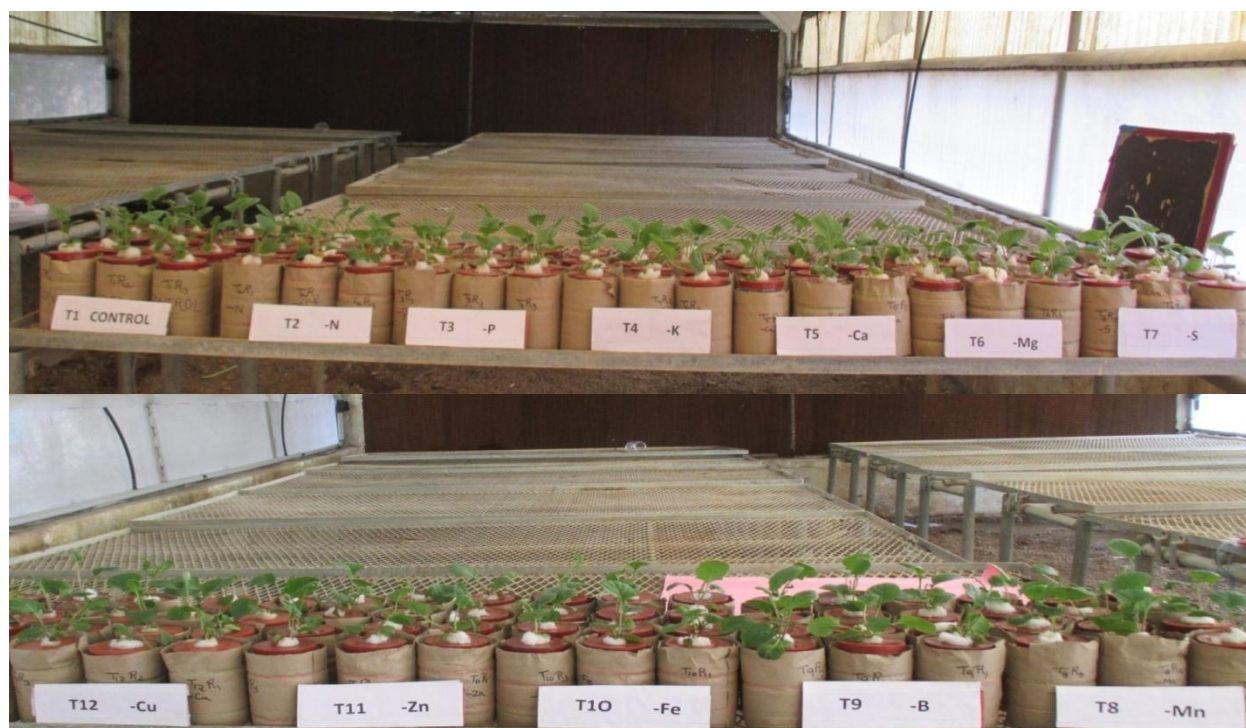


Fig.2 Gerbera plants aerated with aspirator



It can be concluded that, plants grown in complete nutrient solution recorded maximum growth compared to individual deficiency treatments. Under deficiency conditions, content of individual mineral element has been reduced. Deficiency of N had reduced plant growth significantly followed by P, K, Ca, Fe and Mg. Whereas, remaining elements affected plant growth marginally.

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