



Influence of Nutrients and Biostimulants Application on Success Percentage, Leaf Nutrient Status and Physiological Traits of Acid Lime (*Citrus aurantifolia* Swingle) Seedlings cv. Kagzi

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: <https://doi.org/10.9734/ijpss/2025/v37i55447>

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://pr.sdiarticle5.com/review-history/135469>

Original Research Article

Received: 01/03/2025
Accepted: 02/05/2025
Published: 08/05/2025

ABSTRACT

An experiment was conducted during the year 2023-2024 at Fruit Research Station, Imaliya, Department of Horticulture, JNKVV, Jabalpur. It was laid out in 5 x 3 Factorial Completely Randomized Design (FCRD) with the 18 treatment combinations having 3 replications. Factor-A

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Cite as: Shakya, Harendra Kumar, CS Pandey, and Sakshi Mishra. 2025. "Influence of Nutrients and Biostimulants Application on Success Percentage, Leaf Nutrient Status and Physiological Traits of Acid Lime (*Citrus Aurantifolia* Swingle) Seedlings Cv. Kagzi". *International Journal of Plant & Soil Science* 37 (5):229-42. <https://doi.org/10.9734/ijpss/2025/v37i55447>.

consist of 5 levels of inorganic fertilizers (F₀- (Control) Soil: Sand: FYM, F₁- NPK (19:19:19) @ 1 %, F₂-Mono potassium phosphate (0:52:34) @ 1 %, F₃-Potassium nitrate (13:0:45) @ 1 %, F₄-Urea phosphate (17:44:0) @ 1 % and F₅-Potassium sulphate (0:0:50) @ 1 %) and Factor-B with 3 level of bio-stimulants (B₀-Panchagava @10 ml/L, B₁-Sagarika @ 3ml/L and B₂-Krishi Shakti @10ml/L). This experiment was conducted to evaluate the effect of NPK fertilization alone or in combination with other bio-stimulants on Acid Lime seedling development and vigour to quickly produce viable and healthy seedlings. On the basis of the observation obtained in the present investigation, it is concluded that among the inorganic fertilizers (Factor- A), the treatment F₁ (NPK (19:19:19) @ 1%) proved superior over all treatments followed by F₄ (Urea phosphate (17:44:0) @ 1%). Among bio-stimulants (Factor-B), treatment B₂ (Krishi shakti) performed best over other treatments followed by B₁ (Sagarika). The treatment F₁B₂ (NPK (19:19:19) @ 1% + Krishi shakti) in combination was proved superior over rest of the treatment for the parameters like maximum success percentage (100%, 96% and 96%), CGR (0.38 gm⁻²day⁻¹ and 0.48 gm⁻²day⁻¹), RGR (0.022 g/g/day and 0.049 g/g/day), NAR (0.00155 g/m²/day and 0.0024 g/m²/day), Leaf area index (LAI) (0.51, 0.87 and 1.33) and Leaf area Duration (LAD) (191.80 and 226.80) at 60, 90 and 120 DAP. The treatment combination F₁B₁ (NPK (19:19:19) @ 1 % + Sagarika) was found next best treatment in this respect. The treatment F₁B₂ (NPK (19:19:19) @ 1% + Krishi Shakti) was superior for nitrogen content in leaves (1.63%), treatment F₂B₂ (Mono Potassium Phosphate (0:52:34) @ 1% + Krishi Shakti) for phosphorus content in leaves (0.77%) and F₃B₂ (Potassium Nitrate (13:0:45) @ 1% + Krishi Shakti) for potassium content in leaves (1.99%) of acid lime seedling.

Keywords: Acid lime; inorganic fertilizers; bio-stimulants; krishi shakti and sagarika.

1. INTRODUCTION

Citrus is one of the most important fruits of the world and it is cultivated widely in the tropical and sub-tropical regions throughout the globe, having many species. Acid Lime (*Citrus aurantifolia*) is one of the commercially important citrus species grown in India besides Mandarin orange (*Citrus reticulata*), sweet orange (*Citrus sinensis*), lemon (*Citrus limon*), grapefruit (*Citrus paradisi*) and pomelo (*Citrus maxima*). It belongs to the family Rutaceae with chromosome number 2n=18. It is also known as Kagzi lime, Mexican lime or Pati lime (Prajapati et al., 2017).

In India, Kagzi lime is commercially propagated through seeds as it is true to type due to a high degree of nuclear embryony (39–60%). Kagzi lime seeds are recalcitrant in nature. The recalcitrant seeds impose serious storage problems due to their desiccation and chilling sensitivity. Citrus seeds were successfully stored for up to 90 days at 4°C to 7°C, ensuring their viability and achieving good germination. June is the month when ripe fruits devoid of shrivelled seeds provide high-quality seeds (Joshi et al., 2015).

In Kagzi, 98 % of the lime is polyembryonic, meaning that a single seed often produces more than two seedlings. To satisfy the growing demand of the cultivators in the shortest amount of time, greater and faster seed germination and

the generation of the highest number of seedlings are vitally necessary in seed propagated plants (Dilip et al., 2017). However, the percentage of limes that germinate in Kagzi varies from 27% to 58%. The Kagzi lime takes three weeks for it to germinate. Heavy mortality among seedlings in the main nursery stage is the most significant issue with Kagzi lime propagation. Because it contains particular inhibitory substances that prevent early seed germination, the lime seed coat functions as a barrier. The growth of Acid Lime seedlings is very slow in the nursery as well as in the field. In fact, many complaints from cultivators for the slow growth of seedlings under field conditions are being reported.

Plant bio-stimulants are substances and materials, which, when applied to plant, seeds or growing substrates in specific formulations, have the capacity to modify physiological processes of plants in a way that provides potential benefits to growth, development and stress responses” (du Jardin, 2012). Bio-stimulants play a role in physiological processes by regulating the plant hormone signals, enhanced antioxidant systems, promote root development, enhanced nutrient use efficiency and rhizosphere microbial activity (Du Jardin, 2015). The findings are also in close association with Vessey (2003), Roupheal & Colla (2020), Colla et al. (2014) and Canellas et al. (2002). The application of

inorganic fertilizers at required rates gives a positive effect on crop yields and enhances yield improvement in agriculture food production (Akande et al., 2010). Therefore, to raise plants within the shortest possible time, growth has to be accelerated, for which inorganic fertilizers and bio-stimulants are often employed to faster improve the subsequent growth of seedlings (Chaudhary et al., 2020).

2. MATERIALS AND METHODS

The experiment was conducted during February to June, 2024 in the fruit research station, Imaliya, Department of Horticulture, JNKVV, Jabalpur. It was laid out in 5 x 3 Factorial Completely Randomized Design (FCRD) with the 18 treatment combinations having 3 replications. Factor-A consist of 5 levels of inorganic fertilizers (F₀- (Control) Soil: Sand: FYM, F₁- NPK (19:19:19) @ 1 %, F₂-Mono potassium phosphate (0:52:34) @ 1 %, F₃-Potassium nitrate (13:0:45) @ 1 %, F₄-Urea phosphate (17:44:0) @ 1 % and F₅-Potassium sulphate (0:0:50) @ 1 %) and Factor-B with 3 level of bio-stimulants (B₀-Panchagava @10 ml/L, B₁-Sagarika @ 3ml/L and B₂-Krishi Shakti @10ml/L). Planting material was taken from the seedlings that attained the diameter of 2-4 mm in the seed bed, were planted in the polybags. Seedlings with damaged or curved roots were culled. The seedlings of uniform size were selected and transplanted in the polybags (9" x 6" size). The application of inorganic fertilizers and bio-stimulants treatments were given at monthly intervals to the seedlings from March to April. For application preparation of 1% solution of N: P: K (19:19:19), Mono potassium phosphate (00:52:34), Potassium nitrate (13:00:45), Urea phosphate (17:44:00) and Potassium sulphate (00:00:50) solution dissolve 10 g quantity of substance in 1 lit. of distilled water. For preparation of Panchagavya @ 10 ml, Sagarika @ 3 ml and Krishi Shakti @ 10 ml were dissolved in 1 Lit. of distilled water. The application of inorganic fertilizers and bio-stimulants was made in solution form to ensure uniformity in application. Observation on the success percentage at 120 DAP was calculated by using formula (no. of survived seedling / total no of planted seedling) x 100. Physiological parameters i.e. relative growth rate (RGR), Crop growth rate (CGR), Net assimilation rate (NAR), Leaf area index (LAI), Leaf chlorophyll index recorded Leaf area duration (LAD) at 60, 90, 120 DAP. The leaf area index was calculated by leaf area divided by ground area. Leaf Area Duration is the result of integrating LAI over time.

Employing a SPAD chlorophyll meter chlorophyll content index was measured. Utilizing a LUX meter, LTR is measured at two different plant heights (above and below). The ratio of quantum light intercepted by the crop canopy at the top to the bottom was calculated. NAR, CGR, RGR were calculated as per formula given by Williams (1946).

$$NAR = \frac{(\log L2 - \log L1) \times (W2 - W1)}{(L2 - L1) \times (t2 - t1)}$$

$$CGR = \frac{(W2 - W1)}{P(t2 - t1)}$$

$$RGR = \frac{\ln W2 - \ln W1}{t2 - t1}$$

Where,

t₁, t₂ = days of observation

L₁, L₂ = leaf dry weight at t₁ and t₂

W₂, W₁ = Whole plant dry weight at t₁ and t₂

P = Spacing in m²

The leaf nutrient status i.e. Nitrogen content (%), Phosphorus content (%) and Potassium content (%) were recorded at 120 DAP. Nitrogen was estimated by using micro "Kjeldahl" distillation method (AOAC, 1999). Phosphorus concentration was determined by "Vandomolybdo phosphate" yellow colour method (Richards, 1968) and the potassium concentration was determined by "Flame photometric" method (Jackson, 1973). Statistical analysis of data was carried out by applying the technique of analysis of variance (ANOVA) for Factorial Completely Randomized Design (FCRD) using the 'F' test.

3. RESULTS AND DISCUSSION

3.1 Effect of Inorganic Fertilizers

The inorganic fertilizers had shown a significant effect on success percentage. Inorganic nutrient with F₁ i.e. NPK (19:19:19) @ 1 % recorded a maximum success percentage (95 %), followed by treatment F₄ i.e. urea phosphate (17:44:00) @ 1 % with success I percentage (91%) due to the fact that the synthesis of amino acids in plants is accelerated, which might have been indirectly exhibited by enhanced growth. The results are in accordance with the findings of Silas at al. (2023) in sweet orange and Gain et al. (2019) in sweet orange.

Table 1. Treatment combinations

S. No.	Treatment Notations	Treatment detail
1	F ₀ B ₀	Soil: Sand: FYM + Panchagavya
2	F ₀ B ₁	Soil: Sand: FYM + Sagarika
3	F ₀ B ₂	Soil: Sand: FYM + Krishi Shakti
4	F ₁ B ₀	NPK (19:19:19) @ 1 % + Panchagavya
5	F ₁ B ₁	NPK (19:19:19) @ 1 % + Sagarika
6	F ₁ B ₂	NPK (19:19:19) @ 1 % + Krishi Shakti
7	F ₂ B ₀	Mono potassium phosphate (0:52:34) @ 1 % + Panchagavya
8	F ₂ B ₁	Mono potassium phosphate (0:52:34) @ 1 % + Sagarika
9	F ₂ B ₂	Mono potassium phosphate (0:52:34) @ 1 % + Krishi Shakti
10	F ₃ B ₀	Potassium nitrate (13:0:45) @ 1 % + Panchagavya
11	F ₃ B ₁	Potassium nitrate (13:0:45) @ 1 % + Sagarika
12	F ₃ B ₂	Potassium nitrate (13:0:45) @ 1 % + Krishi Shakti
13	F ₄ B ₀	Urea phosphate (17:44:0) @ 1 % + Panchagavya
14	F ₄ B ₁	Urea phosphate (17:44:0) @ 1 % + Sagarika
15	F ₄ B ₂	Urea phosphate (17:44:0) @ 1 % + Krishi Shakti
16	F ₅ B ₀	Potassium sulphate (0:0:50) @ 1 % + Panchagavya
17	F ₅ B ₁	Potassium sulphate (0:0:50) @ 1 % + Sagarika
18	F ₅ B ₂	Potassium sulphate (0:0:50) @ 1 % + Krishi Shakti

Inorganic nutrients had shown a significant effect on seedling crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), leaf area index (LAI), Leaf chlorophyll content and leaf area duration (LAD) at 60, 90, and 120 days after planting. inorganic nutrient with F₁ i.e., NPK (19:19:19) @ 1 % recorded a maximum CGR (0.36 gm⁻² day⁻¹ and 0.76 gm⁻² day⁻¹), RGR (0.021 g/g/day and 0.049 g/g/day), NAR (0.00154 g/m² /day and 0.0055 g/m² /day), leaf area index (LAI) of 0.49, 0.73 and 1.31), chlorophyll content (65.55, 64.84 and 60.11) and leaf area duration (LAD) of 188.10 and 219.77 was calculated under the F₁ (NPK (19:19:19) @ 1%) followed by treatment F₄, i.e., urea phosphate (17:44:00) @ 1%. This may be due to the role of nitrogen in increasing cell size, its elongation and division, which was positively reflected in the increase in vegetative growth indicators or it can be due to the role of nitrogen element, which increases the stored carbohydrate, vegetative growth, increase solubility of each other and photosynthetic efficiency reflected on the plant growth indicators. The results are in accordance with the findings of Al-Meekeh et al. (2020) in Citrus, Koeneni (2016) in Green Gram, Chandana and Dorajeerao (2014) in Gladiolus, Vinod Kumar and Salakinkop (2017) in Groundnut and Baharuddin (2016) in Chilli.

The maximum nitrogen content in leaves (1.56 %) was observed in F₁ with NPK (19:19:19) @ 1

%, followed by F₄ i.e., urea phosphate (17:44:00) @ 1 % with nitrogen content in leaves (1.48 %), The maximum phosphorus content in leaves (0.67 %) was observed in F₂ with Mono Potassium Phosphate (0:52:34) @ 1 %, followed by F₄, i.e., urea phosphate (17:44:00) @ 1% with phosphorus content in leaves (0.58%) and The maximum potassium content in leaves (1.94 %) was observed in F₃ with Potassium Nitrate (13:0:45) @ 1 %, followed by F₅ with Potassium Sulphate (00:00:50) @ 1 % with potassium content in leaves (1,63%). It may be due to nitrogen enhances leaf nitrogen content by promoting cell division and elongation, supporting the synthesis of key biomolecules like amino acids and chlorophyll and improving photosynthesis, nutrient uptake, and carbohydrate accumulation in plant leads to increased vegetative growth and plant vigour, as noted by Ahmed et al. (2022).

3.2 Effect of Bio-stimulants

Bio-stimulants showed a significant effect on success percentage at 120 days after planting. The maximum success percentage (87 %) was recorded under B₂ (Krishi Shakti), followed by treatment B₁ (Sagarika) with success percentage (85%). It may be due to the fact that the bio-stimulant (Krishi Shakti) is a microbial bio-stimulant consortium that introduces beneficial microorganisms into the soil, increasing the availability of elements like phosphorus,

potassium etc. to the crop. The results are in accordance with the findings of Aja and Al-Abbasi (2021) in Acid Lime, Bagul et al. (2018) in Papaya cv. Red Lady and Khan et al. (2022) in Black gram.

Bio-stimulants showed a significant effect on seedling crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), leaf area index (LAI), Leaf chlorophyll content and leaf area duration (LAD) at 60, 90 and 120 days after planting. The maximum CGR (0.20 gm-2day⁻¹ and 0.60 gm-2day⁻¹), RGR (0.013 g/g/day and 0.038 g/g/day), NAR (0.00081 g/m²/day and 0.0040 g/m²/day), leaf area index (LAI) (0.41, 0.60 and 1.07), chlorophyll content (61.87 and 57.41) and leaf area duration (LAD) (170.22 and 201.05), was recorded under B₂ (Krishi shakti), followed by B₁ (Sagarika). This may be due to the role of the bio-stimulant solution in the strength of vegetative growth because it contains several nutrients that meet the need for vegetative growth. This will increase cell division and expansion, then increase the area of the leaves and improve the vegetative growth and nutrition status of the seedlings. The efficiency of photosynthesis and the chlorophyll content of the leaves increase as a result of application. The results are in accordance with the findings of Aja and Al-Abbasi (2021) in Acid Lime, Khazal et al. (2018) in Eggplant, Kakaraparathi et al. (2013) in Ocimum, Mishu et al. (2013) in Onion and Maida et al. (2021) in Onion.

Bio-stimulants also had a significant effect on nitrogen, phosphorus and potassium content in leaves. The maximum nitrogen content in leaves (1.45 %) was noted in B₂ (Krishi Shakti), whereas the minimum nitrogen content in leaves (1.42 %) was observed in B₀ (Panchagavya), The maximum phosphorus content in leaves (0.57 %) was noted in B₂ (Krishi Shakti), whereas the minimum phosphorus content in leaves (0.52 %) was observed in B₀ (Panchagavya) and the maximum potassium content in leaves (1.65 %) was noted in B₂ (Krishi Shakti), followed by B₁ (Sagarika), whereas the minimum potassium content in leaves (1.58 %) was observed in B₀ (Panchagavya) at 120 days after planting. It may be due to the maximum absorption of bio-stimulants from the roots when apply the drenching. It was positively reflected in the increase in the concentration of nutrients inside the plant. These results agreed when drenching Acid Lime seedlings with the bio-stimulant solution of Krishi Shakti; the content of leaves increased for (N, P, K) and these results

are consistent with when treating Acid Lime with a bio-stimulant. The results are in accordance with the findings of Al-Meekeh et al. (2020) in Citrus.

3.3 Interaction Effect of Inorganic Fertilizers and Bio-stimulants

The interaction effect of inorganic fertilizers and bio-stimulants had shown a significant effect on success percentage. The maximum success percentage (96 %) was recorded under F₁B₂ (NPK (19:19:19) @ 1 % + Krishi shakti), followed by treatment F₁B₁ (NPK (19:19:19) @ 1 % + Sagarika). It may be due to the presence of macronutrients (N, P, K, Ca and S) and other micronutrients (Zn, Cu, Mn) that they could have been causes for increased vigour of seedlings, which increase growth parameters of seedlings with the interaction of bio-stimulants and inorganic fertilizers. Bio-stimulants use in combination with inorganic fertilizers has shown synergistic effects, improved nutrient use efficiency, enhanced physiological vigour and increased root development which leads to higher success rates and uniform growth. The results are in accordance with the findings of Bagul et al. (2018) in Papaya cv. Red Lady, Aja et al. (2021) in Acid Lime, Manas et al. (2014) and Zekri et al (2009) in citrus.

The interaction effect of inorganic nutrients and bio-stimulants had shown a significant effect on crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), leaf area index (LAI), Leaf chlorophyll content and leaf area duration (LAD). The maximum CGR (0.38 gm-2day⁻¹ and 0.48 gm-2day⁻¹), RGR (0.022 g/g/day and 0.049 g/g/day), NAR (0.00155 g/m²/day and 0.0024 g/m²/day), leaf area index (LAI) (0.51, 0.87 and 1.33) and leaf area duration (LAD) (191.80 and 226.80) recorded under treatment combination F₁B₂ (NPK (19:19:19) @ 1 % + Krishi shakti). This may be due to the maximum absorption and maximum utilization of inorganic fertilizers and bio-stimulants to enhance the physiological properties of Acid Lime seedling. The results are in accordance with the findings of Mohammed Tarkhan Abo-Meekeh et al. (2020) in Citrus, Vinod Kumar and Salakinkop (2017) in Groundnut and Khazal et al. (2018) in Eggplant.

The interaction effect between inorganic fertilizers and bio-stimulants was found to be significant with nitrogen, phosphorus and potassium content. The maximum nitrogen

content (1.63 %) was recorded under F₁B₂ (NPK (19:19:19) @ 1 % + Krishi shakti), followed by F₁B₁ (NPK (19:19:19) @ 1 % + Sagarika) with nitrogen content in leaves (1.59 %) and minimum nitrogen content (1.33 %) was recorded under F₀B₀ (Soil: Sand: FYM + Panchagavya) at 120 days after planting, The maximum phosphorus content (0.77 %) was recorded under F₂B₂ (Mono Potassium Phosphate (0:52:34) @ 1 % + Krishi Shakti), followed by F₄B₂ (Urea Phosphate (17:44:00) @ 1 % + Krishi Shakti), and minimum phosphorus content (0.44 %) was recorded under F₀B₀ (Soil: Sand: FYM + Panchagavya) and the maximum potassium content (1.99 %) was recorded under F₁B₂ (Potassium Nitrate (13:0:45) @ 1% + Krishi Shakti), followed by F₅B₁ (Potassium Sulphate (00:00:50) @ 1 % +

Krishi Shakti), and minimum potassium content (1.44 %) was recorded under F₀B₀ (Soil: Sand: FYM + Panchagavya) at 120 days after planting. The reason may be due to the maximum utilization of inorganic fertilizers and bio-stimulants and the increased solubility of each other to increase the nutrient content in leaves (Sanjutha et al., 2008). Bio-stimulants improve nutrient use efficiency (NUE) by enhancing root architecture, stimulating microbial activity in the rhizosphere, and increasing nutrient solubility and uptake (Rouphael & Colla, 2020). Inorganic fertilizers provide nutrients in readily available form, combining with bio-stimulants they can significantly improve NUE by increasing the plant's ability to absorb, translocate and assimilate nutrients (Colla et al, 2014).

Table 2. Effect of nutrients and bio-stimulants enriched media on success per cent (%) of seedling at 120 DAP

	Success per cent (%)
Factor- F (Inorganic fertilizers)	
(Control) Soil: Sand: FYM (F ₀)	72
NPK (19:19:19) @ 1 % (F ₁)	95
Mono potassium phosphate (0:52:34) @ 1 % (F ₂)	86
Potassium nitrate (13:0:45) @ 1 % (F ₃)	88
Urea phosphate (17:44:0) @ 1 % (F ₄)	91
Potassium sulphate (0:0:50) @ 1 % (F ₅)	82
SEm (±)	0.659
CD (5%)	1.890
Factor – B (Bio-Stimulants)	
Panchagavya @10 ml/L (B ₀)	84
Sagarika @ 3ml/L (B ₁)	85
Krishi Shakti @10ml/L (B ₂)	87
SEm (±)	0.466
CD (5%)	1.336
Treatment Combinations	
T ₁ (F ₀ B ₀)	68
T ₂ (F ₀ B ₁)	70
T ₃ (F ₀ B ₂)	77
T ₄ (F ₁ B ₀)	92
T ₅ (F ₁ B ₁)	96
T ₆ (F ₁ B ₂)	96
T ₇ (F ₂ B ₀)	85
T ₈ (F ₂ B ₁)	85
T ₉ (F ₂ B ₂)	87
T ₁₀ (F ₃ B ₀)	88
T ₁₁ (F ₃ B ₁)	88
T ₁₂ (F ₃ B ₂)	88
T ₁₃ (F ₄ B ₀)	88
T ₁₄ (F ₄ B ₁)	91
T ₁₅ (F ₄ B ₂)	92
T ₁₆ (F ₅ B ₀)	81
T ₁₇ (F ₅ B ₁)	81
T ₁₈ (F ₅ B ₂)	84
SEm (±)	1.141
CD (5%)	3.274

Table 3. Effect of nutrients and bio-stimulants enriched media on Crop Growth Rate (CGR) (g m⁻²day⁻¹)

	60-90 DAP	90-120 DAP
Factor- F (Inorganic fertilizers)		
(Control) Soil: Sand: FYM (F ₀)	0.05	0.45
NPK (19:19:19) @ 1 % (F ₁)	0.36	0.76
Mono potassium phosphate (0:52:34) @ 1 % (F ₂)	0.12	0.52
Potassium nitrate (13:0:45) @ 1 % (F ₃)	0.19	0.59
Urea phosphate (17:44:0) @ 1 % (F ₄)	0.25	0.65
Potassium sulphate (0:0:50) @ 1 % (F ₅)	0.08	0.48
Sem (±)	0.005	0.009
CD (5%)	0.013	0.026
Factor – B (Bio-Stimulants)		
Panchagavya @10 ml/L (B ₀)	0.16	0.56
Sagarika @ 3ml/L (B ₁)	0.17	0.57
Krishi Shakti @10ml/L (B ₂)	0.20	0.60
Sem (±)	0.003	0.007
CD (5%)	0.009	0.019
Treatment Combinations		
T ₁ (F ₀ B ₀)	0.04	0.44
T ₂ (F ₀ B ₁)	0.05	0.45
T ₃ (F ₀ B ₂)	0.07	0.47
T ₄ (F ₁ B ₀)	0.33	0.73
T ₅ (F ₁ B ₁)	0.37	0.77
T ₆ (F ₁ B ₂)	0.38	0.48
T ₇ (F ₂ B ₀)	0.10	0.50
T ₈ (F ₂ B ₁)	0.12	0.52
T ₉ (F ₂ B ₂)	0.14	0.54
T ₁₀ (F ₃ B ₀)	0.18	0.58
T ₁₁ (F ₃ B ₁)	0.19	0.59
T ₁₂ (F ₃ B ₂)	0.19	0.59
T ₁₃ (F ₄ B ₀)	0.21	0.61
T ₁₄ (F ₄ B ₁)	0.21	0.61
T ₁₅ (F ₄ B ₂)	0.32	0.72
T ₁₆ (F ₅ B ₀)	0.08	0.48
T ₁₇ (F ₅ B ₁)	0.08	0.48
T ₁₈ (F ₅ B ₂)	0.09	0.49
Sem (±)	0.008	0.016
CD (5%)	0.023	0.046

Table 4. Effect of nutrients and bio-stimulants enriched media on Relative Growth Rate (RGR) (g/g/day)

	60-90 DAP	90-120 DAP
Factor- F (Inorganic fertilizers)		
(Control) Soil: Sand: FYM (F ₀)	0.007	0.028
NPK (19:19:19) @ 1 % (F ₁)	0.021	0.049
Mono potassium phosphate (0:52:34) @ 1 % (F ₂)	0.010	0.035
Potassium nitrate (13:0:45) @ 1 % (F ₃)	0.013	0.037
Urea phosphate (17:44:0) @ 1 % (F ₄)	0.015	0.039
Potassium sulphate (0:0:50) @ 1 % (F ₅)	0.008	0.033
Sem (±)	0.000289	0.000319
CD (5%)	0.000829	0.000915
Factor – B (Bio-Stimulants)		
Panchagavya @10 ml/L (B ₀)	0.011	0.036
Sagarika @ 3ml/L (B ₁)	0.012	0.037

	60-90 DAP	90-120 DAP
Krishi Shakti @10ml/L (B ₂)	0.013	0.038
Sem (±)	0.000204	0.000226
CD (5%)	0.000586	0.000647
Treatment Combinations		
T ₁ (F ₀ B ₀)	0.006	0.025
T ₂ (F ₀ B ₁)	0.007	0.028
T ₃ (F ₀ B ₂)	0.007	0.030
T ₄ (F ₁ B ₀)	0.020	0.048
T ₅ (F ₁ B ₁)	0.021	0.049
T ₆ (F ₁ B ₂)	0.022	0.049
T ₇ (F ₂ B ₀)	0.009	0.035
T ₈ (F ₂ B ₁)	0.009	0.035
T ₉ (F ₂ B ₂)	0.011	0.036
T ₁₀ (F ₃ B ₀)	0.011	0.037
T ₁₁ (F ₃ B ₁)	0.013	0.037
T ₁₂ (F ₃ B ₂)	0.014	0.037
T ₁₃ (F ₄ B ₀)	0.014	0.037
T ₁₄ (F ₄ B ₁)	0.014	0.040
T ₁₅ (F ₄ B ₂)	0.018	0.041
T ₁₆ (F ₅ B ₀)	0.007	0.032
T ₁₇ (F ₅ B ₁)	0.008	0.032
T ₁₈ (F ₅ B ₂)	0.008	0.035
Sem (±)	0.000501	0.000553
CD (5%)	0.001436	0.001585

Table 5. Effect of nutrients and bio-stimulants enriched media on Net Assimilation Rate (NAR) In g/m²/day

	60-90 DAP	90-120 DAP
Factor- F (Inorganic fertilizers)		
(Control) Soil: Sand: FYM (F ₀)	0.00024	0.0026
NPK (19:19:19) @ 1 % (F ₁)	0.00154	0.0055
Mono potassium phosphate (0:52:34) @ 1 % (F ₂)	0.00050	0.0035
Potassium nitrate (13:0:45) @ 1 % (F ₃)	0.00071	0.0039
Urea phosphate (17:44:0) @ 1 % (F ₄)	0.00103	0.0043
Potassium sulphate (0:0:50) @ 1 % (F ₅)	0.00033	0.0032
SEm (±)	0.000021	0.000063
CD (5%)	0.000059	0.000182
Factor – B (Bio-Stimulants)		
Panchagavya @10 ml/L (B ₀)	0.00065	0.0036
Sagarika @ 3ml/L (B ₁)	0.00072	0.0038
Krishi Shakti @10ml/L (B ₂)	0.00081	0.0040
SEm (±)	0.000015	0.000045
CD (5%)	0.000042	0.000129
Treatment Combinations		
T ₁ (F ₀ B ₀)	0.00018	0.0024
T ₂ (F ₀ B ₁)	0.00025	0.0027
T ₃ (F ₀ B ₂)	0.00030	0.0028
T ₄ (F ₁ B ₀)	0.00153	0.0049
T ₅ (F ₁ B ₁)	0.001552	0.0055
T ₆ (F ₁ B ₂)	0.001559	0.0060
T ₇ (F ₂ B ₀)	0.00040	0.0034
T ₈ (F ₂ B ₁)	0.00054	0.0034
T ₉ (F ₂ B ₂)	0.00055	0.0035
T ₁₀ (F ₃ B ₀)	0.00067	0.0038

	60-90 DAP	90-120 DAP
T ₁₁ (F ₃ B ₁)	0.00068	0.0038
T ₁₂ (F ₃ B ₂)	0.00078	0.0040
T ₁₃ (F ₄ B ₀)	0.00080	0.0041
T ₁₄ (F ₄ B ₁)	0.00096	0.0041
T ₁₅ (F ₄ B ₂)	0.00132	0.0046
T ₁₆ (F ₅ B ₀)	0.00031	0.0032
T ₁₇ (F ₅ B ₁)	0.00032	0.0032
T ₁₈ (F ₅ B ₂)	0.00037	0.0033
SEm (±)	0.000036	0.000110
CD (5%)	0.000102	0.000315

Table 6. Effect of nutrients and bio-stimulants enriched media on Leaf Area Index (LAI)

	60 DAP	90 DAP	120 DAP
Factor- F (Inorganic fertilizers)			
(Control) Soil: Sand: FYM (F ₀)	0.31	0.40	0.66
NPK (19:19:19) @ 1 % (F ₁)	0.49	0.73	1.31
Mono potassium phosphate (0:52:34) @ 1 % (F ₂)	0.37	0.53	1.01
Potassium nitrate (13:0:45) @ 1 % (F ₃)	0.40	0.58	1.08
Urea phosphate (17:44:0) @ 1 % (F ₄)	0.44	0.62	1.19
Potassium sulphate (0:0:50) @ 1 % (F ₅)	0.34	0.47	0.90
SEm (±)	0.004	0.015	0.014
CD (5%)	0.011	0.042	0.039
Factor – B (Bio-Stimulants)			
Panchagavya @10 ml/L (B ₀)	0.38	0.52	0.98
Sagarika @ 3ml/L (B ₁)	0.40	0.55	1.02
Krishi Shakti @10ml/L (B ₂)	0.41	0.60	1.07
SEm (±)	0.003	0.010	0.010
CD (5%)	0.007	0.030	0.028
Treatment Combinations			
T ₁ (F ₀ B ₀)	0.27	0.37	0.60
T ₂ (F ₀ B ₁)	0.32	0.41	0.61
T ₃ (F ₀ B ₂)	0.33	0.44	0.78
T ₄ (F ₁ B ₀)	0.48	0.64	1.30
T ₅ (F ₁ B ₁)	0.48	0.69	1.31
T ₆ (F ₁ B ₂)	0.51	0.87	1.33
T ₇ (F ₂ B ₀)	0.36	0.51	0.98
T ₈ (F ₂ B ₁)	0.37	0.53	1.01
T ₉ (F ₂ B ₂)	0.38	0.55	1.05
T ₁₀ (F ₃ B ₀)	0.39	0.56	1.05
T ₁₁ (F ₃ B ₁)	0.41	0.57	1.08
T ₁₂ (F ₃ B ₂)	0.42	0.60	1.11
T ₁₃ (F ₄ B ₀)	0.42	0.60	1.12
T ₁₄ (F ₄ B ₁)	0.45	0.63	1.22
T ₁₅ (F ₄ B ₂)	0.45	0.63	1.23
T ₁₆ (F ₅ B ₀)	0.33	0.45	0.86
T ₁₇ (F ₅ B ₁)	0.34	0.45	0.91
T ₁₈ (F ₅ B ₂)	0.35	0.50	0.92
SEm (±)	0.006	0.026	0.024
CD (5%)	0.018	0.074	0.068

Table 7. Effect of nutrients and bio-stimulants enriched media on Leaf Chlorophyll content (SPAD value)

	60 DAP	90 DAP	120 DAP
Factor- F (Inorganic fertilizers)			
(Control) Soil: Sand: FYM (F ₀)	58.83	57.61	52.91
NPK (19:19:19) @ 1 % (F ₁)	65.55	64.84	60.11
Mono potassium phosphate (0:52:34) @ 1 % (F ₂)	62.02	61.16	56.81
Potassium nitrate (13:0:45) @ 1 % (F ₃)	62.82	61.71	57.50
Urea phosphate (17:44:0) @ 1 % (F ₄)	63.38	62.59	58.42
Potassium sulphate (0:0:50) @ 1 % (F ₅)	60.83	59.94	54.84
SEm (±)	0.476	0.307	0.473
CD (5%)	1.365	0.879	1.357
Factor – B (Bio-Stimulants)			
Panchagavya @10 ml/L (B ₀)	61.47	60.83	56.15
Sagarika @ 3ml/L (B ₁)	62.16	61.23	56.76
Krishi Shakti @10ml/L (B ₂)	62.59	61.87	57.41
SEm (±)	0.337	0.217	0.335
CD (5%)	NS	0.622	0.959
Treatment Combinations			
T ₁ (F ₀ B ₀)	56.87	56.36	52.33
T ₂ (F ₀ B ₁)	59.33	57.87	52.61
T ₃ (F ₀ B ₂)	60.31	58.59	53.83
T ₄ (F ₁ B ₀)	64.20	64.46	58.84
T ₅ (F ₁ B ₁)	64.23	64.89	60.63
T ₆ (F ₁ B ₂)	65.22	65.18	60.88
T ₇ (F ₂ B ₀)	61.18	60.93	56.36
T ₈ (F ₂ B ₁)	62.42	61.14	57.02
T ₉ (F ₂ B ₂)	62.45	61.42	57.06
T ₁₀ (F ₃ B ₀)	62.69	61.64	57.20
T ₁₁ (F ₃ B ₁)	62.87	61.66	57.32
T ₁₂ (F ₃ B ₂)	62.90	61.84	57.99
T ₁₃ (F ₄ B ₀)	63.23	61.95	58.02
T ₁₄ (F ₄ B ₁)	62.35	62.06	58.53
T ₁₅ (F ₄ B ₂)	63.55	63.77	58.72
T ₁₆ (F ₅ B ₀)	60.64	59.63	54.14
T ₁₇ (F ₅ B ₁)	60.76	59.75	54.43
T ₁₈ (F ₅ B ₂)	61.09	60.43	55.96
SEm (±)	0.824	0.531	0.819
CD (5%)	NS	NS	NS

Table 8. Effect of nutrients and bio-stimulants enriched media on Leaf Area Duration (LAD)

	60-90 DAP	90-120 DAP
Factor- F (Inorganic fertilizers)		
(Control) Soil: Sand: FYM (F ₀)	140.20	168.50
NPK (19:19:19) @ 1 % (F ₁)	188.10	219.77
Mono potassium phosphate (0:52:34) @ 1 % (F ₂)	165.90	195.90
Potassium nitrate (13:0:45) @ 1 % (F ₃)	169.27	199.27
Urea phosphate (17:44:0) @ 1 % (F ₄)	179.77	209.77
Potassium sulphate (0:0:50) @ 1 % (F ₅)	158.47	188.47
SEm (±)	1.169	1.707
CD (5%)	3.352	4.896
Factor – B (Bio-Stimulants)		
Panchagavya @10 ml/L (B ₀)	162.98	192.13

	60-90 DAP	90-120 DAP
Sagarika @ 3ml/L (B ₁)	167.65	197.65
Krishi Shakti @10ml/L (B ₂)	170.22	201.05
SEm (±)	0.826	1.207
CD (5%)	2.370	3.462
Treatment Combinations		
T ₁ (F ₀ B ₀)	129.80	154.70
T ₂ (F ₀ B ₁)	142.20	172.20
T ₃ (F ₀ B ₂)	148.60	178.60
T ₄ (F ₁ B ₀)	184.20	214.20
T ₅ (F ₁ B ₁)	188.30	218.30
T ₆ (F ₁ B ₂)	191.80	226.80
T ₇ (F ₂ B ₀)	163.90	193.90
T ₈ (F ₂ B ₁)	166.80	196.80
T ₉ (F ₂ B ₂)	167.00	197.00
T ₁₀ (F ₃ B ₀)	167.50	197.50
T ₁₁ (F ₃ B ₁)	169.80	199.80
T ₁₂ (F ₃ B ₂)	170.50	200.50
T ₁₃ (F ₄ B ₀)	177.90	207.90
T ₁₄ (F ₄ B ₁)	179.20	209.20
T ₁₅ (F ₄ B ₂)	182.20	212.20
T ₁₆ (F ₅ B ₀)	154.60	184.60
T ₁₇ (F ₅ B ₁)	159.60	189.60
T ₁₈ (F ₅ B ₂)	161.20	191.20
SEm (±)	2.024	2.956
CD (5%)	5.806	8.479

Table 9. Effect of nutrients and bio-stimulants enriched media on Nitrogen, Phosphorous and Potassium content in leaves (%) at 120 DAP

	Nitrogen content	Phosphorus content	Potassium content
Factor- F (Inorganic fertilizers)			
(Control) Soil: Sand: FYM (F ₀)	1.33	0.45	1.46
NPK (19:19:19) @ 1 % (F ₁)	1.56	0.55	1.53
Mono potassium phosphate (0:52:34) @ 1 % (F ₂)	1.43	0.67	1.57
Potassium nitrate (13:0:45) @ 1 % (F ₃)	1.44	0.52	1.94
Urea phosphate (17:44:0) @ 1 % (F ₄)	1.48	0.58	1.50
Potassium sulphate (0:0:50) @ 1 % (F ₅)	1.39	0.50	1.63
SEm (±)	0.014	0.012	0.017
CD (5%)	0.039	0.033	0.048
Factor – B (Bio-Stimulants)			
Panchagavya @10 ml/L (B ₀)	1.42	0.52	1.58
Sagarika @ 3ml/L (B ₁)	1.45	0.54	1.59
Krishi Shakti @10ml/L (B ₂)	1.45	0.57	1.65
SEm (±)	0.010	0.008	0.012
CD (5%)	0.027	0.023	0.034
Treatment Combinations			
T ₁ (F ₀ B ₀)	1.33	0.44	1.44
T ₂ (F ₀ B ₁)	1.34	0.46	1.46
T ₃ (F ₀ B ₂)	1.32	0.47	1.47
T ₄ (F ₁ B ₀)	1.47	0.54	1.52
T ₅ (F ₁ B ₁)	1.59	0.55	1.52
T ₆ (F ₁ B ₂)	1.63	0.56	1.53

	Nitrogen content	Phosphorus content	Potassium content
T ₇ (F ₂ B ₀)	1.43	0.62	1.54
T ₈ (F ₂ B ₁)	1.43	0.64	1.55
T ₉ (F ₂ B ₂)	1.42	0.77	1.63
T ₁₀ (F ₃ B ₀)	1.42	0.51	1.90
T ₁₁ (F ₃ B ₁)	1.45	0.52	1.93
T ₁₂ (F ₃ B ₂)	1.46	0.53	1.99
T ₁₃ (F ₄ B ₀)	1.49	0.57	1.49
T ₁₄ (F ₄ B ₁)	1.48	0.58	1.50
T ₁₅ (F ₄ B ₂)	1.49	0.59	1.51
T ₁₆ (F ₅ B ₀)	1.38	0.49	1.56
T ₁₇ (F ₅ B ₁)	1.39	0.51	1.57
T ₁₈ (F ₅ B ₂)	1.40	0.52	1.77
SEm (±)	0.023	0.020	0.029
CD (5%)	0.067	0.057	0.083

4. CONCLUSION

On the basis of the observation obtained in the present investigation, it is concluded that among the inorganic fertilizers, the treatment F₁ (NPK (19:19:19) @ 1%) followed by Urea phosphate (17:44:0) @ 1% (F₄), among Bio-Stimulants, treatment B₂ (Krishi shakti) followed by B₁ (Sagarika) separately and the treatment F₁B₂ (NPK (19:19:19) @ 1% + Krishi shakti) in combination was proved superior over rest of the treatment for the parameters like success percentage, CGR, RGR, NAR, Leaf area index (LAI) and Leaf area Duration (LAD) at 60, 90 and 120 DAP. The treatment F₁B₂, F₂B₂, F₃B₂ was found superior for nitrogen, phosphorus and potassium content in leaves of acid lime seedling respectively.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

AKNOWLEDGEMENT

I would like to express my sincere gratitude to the departments of horticulture and plant physiology, and soil science JNKVV, Jabalpur for providing all sorts of assistance and cooperation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- Ahmed, A., Shah, S. H., Khan, M. A., & Jan, M. T. 2022. Influence of nitrogen fertilization on growth, yield and quality of apple (*Malus domestica* Borkh.). *Journal of Plant Nutrition*, 45(12), 1804–1814. <https://doi.org/10.1080/01904167.2022.2053356>
- Aja KJ and Al-Abbasi GBA. 2021. Study of Foliar Application of Nutritional Solution and Seaweeds Extract on Growth of Limes (*Citrus Aurantifolia*). In IOP Conference Series: Earth and Environmental Science 910(1): 012-121.
- Akande MO, Oluwatoyinbo FI, Makinde EA, Adepoju AS, Adepoju IS. 2010. Response of okra to organic and inorganic fertilization. *Nat Sci*. 8(11): 261-266.
- Al-Meeh MTA, Alkarawi HH, Asi SL and Al-Ameer HKA. 2020. Effect of Spraying urea and addition of Potassium on growth parameters of Local Citrus seedling (*Citrus sinensis* L.) Grafted on Sour Orange Rootstock. *Indian Journal of Ecology* 47(2): 351-356.
- Bagul HB, Parmar AB, Parma, BR, Pandey AK and Jnanendra M. 2018. Effect of pre-sowing seed treatments on germination and growth of Papaya (*Carica Papaya* L.) seedlings cv. Red Lady. *The Pharma Innovation Journal* 7: 95-97.
- Baharuddin R. 2016. Response to Growth and Yield of Chili (*Capsicum annum* L.) on Reduction of Dose NPK 16:16:16 with Organic Fertilizer. *Journal Dinamika Pertanian* 32(2): 115-124.
- Canellas, L.P., Olivares, F.L., Okorokova-Façanha, A.L., & Façanha, A.R. 2002.

- Humic acids isolated from earthworm compost enhance root elongation, lateral root emergence, and plasma membrane H⁺-ATPase activity in maize roots. *Plant Physiology*, 130(4), 1951–1957.
- Chandana K. and Dorajeerao AVD. 2014. Effect of graded levels of nitrogen and phosphorus on growth and yield of gladiolus (*Gladiolus grandifloras* L.) cv. White prosperity in coastal A.P., India. *Plant Archives* 14(1): 143-50.
- Chaudhary A, Ahlawat TR, Kumar S, Patel D and Jena S. 2020. Promoting seedling growth in Kagzi lime through pre-sowing treatments. *International Journal of Chemical Studies* 8(1): 2815-2819.
- Colla, G., Roupshael, Y., Canaguier, R., Svecova, E., & Cardarelli, M. 2014. Biostimulant action of a plant-derived protein hydrolysate produced through enzymatic hydrolysis. *Frontiers in Plant Science*, 5, 448.
- Dilip WS, Singh D, Moharana D, Rout S and Patra SS. 2017. Influence of Gibberellic acid (GA₃) on seed germination and seedling growth of Kagzi Lime. *Journal of Scientific Agriculture* (1): 62-69.
- Du Jardin, P. 2012. The science of plant bio-stimulants-a bibliographic analysis. Contract 30-CE0455515/00-96, ad hoc study on bio-stimulants products.
- Du Jardin, P. 2015. Plant bio-stimulants: Definition, concept, main categories and regulation. *Scientia Horticulturae*, 196, 3–14.
- Gain S, Prasad VM, Singh S, Pal AK and Kumar R. 2019. Effect of NPK along with FYM and Poultry manures on growth, flowering and fruiting of four year old sweet orange (*Citrus sinensis* L.). *Journal of Pharmacognosy and Phytochemistry* 8(3): 553-555.
- Joshi PS, Sahoo AK, Bhojar RK and Meshram PC. 2015. Effect of various plant growth promoting substances on seedling growth of Acid Lime. *Trends in Biosciences* 8(19): 5222-5225.
- Kakaraparthi PS, Rajput DK and Arigarui NK. 2013. Response of *Ocimum tenuiflorum* variety CIM-AYU to sulphur fertilization in the semi-arid tropical region of Deccan plateau in India. *International Journal of Scientific Research* 2(10): 1-6.
- Khan PMI, Verma R, Dawson J and Singh M. 2022. Effect of Panchagavya and organic manures on growth and yield of blackgram (*Vigna mungo* L.) The *Pharma Innovation Journal* 11(4): 1483-1487.
- Khazaal ZH and Rashed ZS. 2018. Effects of cultivars and the spraying with seaweed extract (*Tecamin algae*) in the growth and yield of eggplant (*Solanum melongena* L.). *Euphrates Journal of Agriculture Science* 10(2): 1-6.
- Koneni S. 2016. Effect of Soil and Foliar Application of Phosphorus on Growth of Green Gram (*Vigna radiata* L.). *Biosciences*: 14.
- Maida SK, Singh SS, Jadia M and Verma KS 2021. Effect of different integrated approaches of organic and inorganic fertilization on quality of onion (*Allium cepa* L.). *Journal of Pharmacognosy and Phytochemistry* 10(1): 2483-2486.
- Manas D, Bandopadhyay PK, Chakravart A, Pal S and Bhattacharya A. 2014. Effect of foliar application of humic acid, zinc and boron on biochemical changes related to productivity of pungent pepper (*Capsicum annum* L.). *African Journal Plant Science* 8(6): 320-335.
- Mishu HM, Ahmed F, Rafii MY, Gola F and Latif MA. 2013. Effect of sulphur on growth, yield and yield attributes in onion (*Allium cepa* L.). *Australian Journal of Crop Science* 7(9): 1416-22.
- Prajapati DG, Satodiya BN, Desai AB and Nagar PK. 2017. Influence of storage period and growing media on seed germination and growth of Acid Lime seedlings (*Citrus aurantifolia* Swingle) Cv. Kagzi. *Journal of Pharmacognosy and Phytochemistry* 6(4): 1641-1645.
- Roupshael, Y., & Colla, G. 2020. Bio-stimulants in agriculture. *Frontiers in Plant Science*, 11, 40.
- Sanjutha S, Subramanian S, Indu Rani C and Maheswari. 2008. Integrated nutrient management in andrographis paniculata. *Research journal of agriculture and biological* 4(2): 141-145.
- Silas VJ and Kumar J. 2023. Effect of Different NPK Levels and Chlorophyll Content on Growth and Development of Sweet Orange (*Citrus sinensis* Osbeck). *International Journal of Environment and Climate Change* 13(12): 522-526.
- Vessey, J.K. 2003. Plant growth promoting rhizobacteria as biofertilizers. *Plant and Soil*, 255, 571–586.

- Vinod Kumar HM and Salakinkop SR. 2017. Growth analysis in groundnut (*Arachis hypogea* L.) as influenced by foliar nutrition. Legume Research 40(6): 1072-1077.
- Zekri, M., & Obreza, T.A. 2009. Plant nutrient needs and fertilization. In: *Citrus Nutrition Management*. University of Florida IFAS Extension.

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