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

**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 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 biostimulants ( 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 biostimulants 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 biostimulants (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 phosphorous 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.

**Key words:** acid lime, inorganic fertilizers, biostimulants, krishi shakti and sagarika

**INTRODUCTION**

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**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 nucellar 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 shriveled 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 biostimulants 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)](https://www.frontiersin.org/journals/plant-science/articles/10.3389/fpls.2020.00040/full#B7). Bio stimulants play role in physiological process by regulating the plant hormone signals, enhanced antioxidant systems, promote root development, **Enhance nutrient use efficiency and** rhizosphere microbial activity. Findings are supported by Du Jardin (2015), Vessey (2003), Rouphael & 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 biostimulants are often employed to faster improve the subsequent growth of seedlings (Chaudhary *et al.,* 2020).

**Material 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 biostimulants ( 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 of curved roots were culled. The seedlings of uniform size were selected and transplanted in the polybags (9” × 6” size). The application of inorganic fertilizers and biostimulants 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 biostimulants 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 divide 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).

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 phophate yellow colour method (Richards, 1968) and 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 ‘F’ test.

**Table 1. Treatment combinations**

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| **S. No.** | **Treatment**  **Notations** | **Treatment detail** |
| 1 | F0 B0 | Soil: Sand: FYM + Panchagavya |
| 2 | F0 B1 | Soil: Sand: FYM + Sagarika |
| 3 | F0 B2 | Soil: Sand: FYM + Krishi Shakti |
| 4 | F1 B0 | NPK (19:19:19) @ 1 % + Panchagavya |
| 5 | F1 B1 | NPK (19:19:19) @ 1 % + Sagarika |
| 6 | F1 B2 | NPK (19:19:19) @ 1 % + Krishi Shakti |
| 7 | F2 B0 | Mono potassium phosphate (0:52:34) @ 1 % + Panchagavya |
| 8 | F2 B1 | Mono potassium phosphate (0:52:34) @ 1 % + Sagarika |
| 9 | F2 B2 | Mono potassium phosphate (0:52:34) @ 1 % + Krishi Shakti |
| 10 | F3 B0 | Potassium nitrate (13:0:45) @ 1 % + Panchagavya |
| 11 | F3 B1 | Potassium nitrate (13:0:45) @ 1 % + Sagarika |
| 12 | F3 B2 | Potassium nitrate (13:0:45) @ 1 % +Krishi Shakti |
| 13 | F4 B0 | Urea phosphate (17:44:0) @ 1 % + Panchagavya |
| 14 | F4 B1 | Urea phosphate (17:44:0) @ 1 % + Sagarika |
| 15 | F4 B2 | Urea phosphate (17:44:0) @ 1 % + Krishi Shakti |
| 16 | F5 B0 | Potassium sulphate (0:0:50) @ 1 % + Panchagavya |
| 17 | F5 B1 | Potassium sulphate (0:0:50) @ 1 % + Sagarika |
| 18 | F5 B2 | Potassium sulphate (0:0:50) @ 1 % + Krishi Shakti |

**Result and Discussion**

**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 l 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.

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-Meekh *et al.* (2020) in Citrus, Koneni (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, leading to increased vegetative growth and plant vigour, as noted by Ahmed et al. (2022).

**Effect of biostimulants**

Biostimulants 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 biostimulant (Krishi Shakti) is a microbial biostimulant consortium that introduces beneficial microorganisms into the soil, increases 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 Blackgram.

Biostimulants 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 biostimulant 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, Kakaraparthi *et al.* (2013) in Ocimum, Mishu *et al.* (2013) in Onion and Maida *et al.* (2021) in Onion.

Biostimulants 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 biostimulants from the roots when adding 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 biostimulant 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 biostimulant. The results are in accordance with the findings of Al-Meekh et al. (2020) in Citrus.

**Interaction Effect of inorganic fertilizers and biostimulants**

The interaction effect of inorganic fertilizers and biostimulants 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 inorganic fertilizer and biostimulants. Biostimulants use in combination with inorganic fertilizers has shown synergistic effects improved nutrient use efficiency, enhanced physiological vigor, increase root development which leads to higher success rates and uniform growth. The results are in line 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 biostimulants 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 tratment combination F1B2 (NPK (19:19:19) @ 1 % + Krishi shakti). This may be due to the maximum absorption and maximum utilization of inorganic fertilizers and biostimulants to enhance the physiological properties of Acid Lime seedling. The results are in accordance with the findings of Mohammed Tarkhan Abo-Meekh *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 biostimulants 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 biostimulants and the increased solubility of each other to increase the nutrient content in leaves (Sanjutha et al., 2008). Biostimulants 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 biostimulants with inorganic fertilizers can significantly improve NUE by increasing the plant's ability to absorb, translocate, and assimilate nutrients (Colla et al, 2014).

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| **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 (F0)** | 72 |
| **NPK (19:19:19) @ 1 % (F1)** | 95 |
| **Mono potassium phosphate (0:52:34) @ 1 % (F2)** | 86 |
| **Potassium nitrate(13:0:45) @ 1 % (F3)** | 88 |
| **Urea phosphate (17:44:0) @ 1 % (F4)** | 91 |
| **Potassium sulphate (0:0:50) @ 1 % (F5)** | 82 |
| **SEm (±)** | 0.659 |
| **CD (5%)** | 1.890 |
| **Factor – B (Bio-Stimulants)** |  |
| **Panchagavya @10 ml/L (B0)** | 84 |
| **Sagarika @ 3ml/L (B1)** | 85 |
| **Krishi Shakti @10ml/L (B2)** | 87 |
| **SEm (±)** | 0.466 |
| **CD (5%)** | 1.336 |
| **Treatment Combinations** |  |
| **T1 (F0 B0)** | 68 |
| **T2 (F0 B1)** | 70 |
| **T3(F0 B2)** | 77 |
| **T4(F1B0)** | 92 |
| **T5(F1B1)** | 96 |
| **T6(F1 B2)** | 96 |
| **T7(F2 B0)** | 85 |
| **T8(F2 B1)** | 85 |
| **T9(F2 B2)** | 87 |
| **T10(F3 B0)** | 88 |
| **T11(F3 B1)** | 88 |
| **T12(F3 B2)** | 88 |
| **T13(F4 B0)** | 88 |
| **T14(F4 B1)** | 91 |
| **T15(F4 B2)** | 92 |
| **T16(F5 B0)** | 81 |
| **T17(F5 B1)** | 81 |
| **T18(F5 B2)** | 84 |
| **SEm (±)** | 1.141 |
| **CD (5%)** | 3.274 |

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| **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 (F0)** | 0.05 | 0.45 |
| **NPK (19:19:19) @ 1 % (F1)** | 0.36 | 0.76 |
| **Mono potassium phosphate (0:52:34) @ 1 % (F2)** | 0.12 | 0.52 |
| **Potassium nitrate(13:0:45) @ 1 % (F3)** | 0.19 | 0.59 |
| **Urea phosphate (17:44:0) @ 1 % (F4)** | 0.25 | 0.65 |
| **Potassium sulphate (0:0:50) @ 1 % (F5)** | 0.08 | 0.48 |
| **SEm (±)** | 0.005 | 0.009 |
| **CD (5%)** | 0.013 | 0.026 |
| **Factor – B (Bio-Stimulants)** |  |  |
| **Panchagavya @10 ml/L (B0)** | 0.16 | 0.56 |
| **Sagarika @ 3ml/L (B1)** | 0.17 | 0.57 |
| **Krishi Shakti @10ml/L (B2)** | 0.20 | 0.60 |
| **SEm (±)** | 0.003 | 0.007 |
| **CD (5%)** | 0.009 | 0.019 |
| **Treatment Combinations** |  |  |
| **T1 (F0 B0)** | 0.04 | 0.44 |
| **T2 (F0 B1)** | 0.05 | 0.45 |
| **T3(F0 B2)** | 0.07 | 0.47 |
| **T4(F1B0)** | 0.33 | 0.73 |
| **T5(F1B1)** | 0.37 | 0.77 |
| **T6(F1 B2)** | 0.38 | 0.48 |
| **T7(F2 B0)** | 0.10 | 0.50 |
| **T8(F2 B1)** | 0.12 | 0.52 |
| **T9(F2 B2)** | 0.14 | 0.54 |
| **T10(F3 B0)** | 0.18 | 0.58 |
| **T11(F3 B1)** | 0.19 | 0.59 |
| **T12(F3 B2)** | 0.19 | 0.59 |
| **T13(F4 B0)** | 0.21 | 0.61 |
| **T14(F4 B1)** | 0.21 | 0.61 |
| **T15(F4 B2)** | 0.32 | 0.72 |
| **T16(F5 B0)** | 0.08 | 0.48 |
| **T17(F5 B1)** | 0.08 | 0.48 |
| **T18(F5 B2)** | 0.09 | 0.49 |
| **SEm (±)** | 0.008 | 0.016 |
| **CD (5%)** | 0.023 | 0.046 |

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| **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 (F0)** | 0.007 | 0.028 |
| **NPK (19:19:19) @ 1 % (F1)** | 0.021 | 0.049 |
| **Mono potassium phosphate (0:52:34) @ 1 % (F2)** | 0.010 | 0.035 |
| **Potassium nitrate(13:0:45) @ 1 % (F3)** | 0.013 | 0.037 |
| **Urea phosphate (17:44:0) @ 1 % (F4)** | 0.015 | 0.039 |
| **Potassium sulphate (0:0:50) @ 1 % (F5)** | 0.008 | 0.033 |
| **SEm (±)** | 0.000289 | 0.000319 |
| **CD (5%)** | 0.000829 | 0.000915 |
| **Factor – B (Bio-Stimulants)** |  |  |
| **Panchagavya @10 ml/L (B0)** | 0.011 | 0.036 |
| **Sagarika @ 3ml/L (B1)** | 0.012 | 0.037 |
| **Krishi Shakti @10ml/L (B2)** | 0.013 | 0.038 |
| **SEm (±)** | 0.000204 | 0.000226 |
| **CD (5%)** | 0.000586 | 0.000647 |
| **Treatment Combinations** |  |  |
| **T1 (F0 B0)** | 0.006 | 0.025 |
| **T2 (F0 B1)** | 0.007 | 0.028 |
| **T3(F0 B2)** | 0.007 | 0.030 |
| **T4(F1B0)** | 0.020 | 0.048 |
| **T5(F1B1)** | 0.021 | 0.049 |
| **T6(F1 B2)** | 0.022 | 0.049 |
| **T7(F2 B0)** | 0.009 | 0.035 |
| **T8(F2 B1)** | 0.009 | 0.035 |
| **T9(F2 B2)** | 0.011 | 0.036 |
| **T10(F3 B0)** | 0.011 | 0.037 |
| **T11(F3 B1)** | 0.013 | 0.037 |
| **T12(F3 B2)** | 0.014 | 0.037 |
| **T13(F4 B0)** | 0.014 | 0.037 |
| **T14(F4 B1)** | 0.014 | 0.040 |
| **T15(F4 B2)** | 0.018 | 0.041 |
| **T16(F5 B0)** | 0.007 | 0.032 |
| **T17(F5 B1)** | 0.008 | 0.032 |
| **T18(F5 B2)** | 0.008 | 0.035 |
| **SEm (±)** | 0.000501 | 0.000553 |
| **CD (5%)** | 0.001436 | 0.001585 |

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| **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 (F0)** | 0.00024 | 0.0026 |
| **NPK (19:19:19) @ 1 % (F1)** | 0.00154 | 0.0055 |
| **Mono potassium phosphate (0:52:34) @ 1 % (F2)** | 0.00050 | 0.0035 |
| **Potassium nitrate(13:0:45) @ 1 % (F3)** | 0.00071 | 0.0039 |
| **Urea phosphate (17:44:0) @ 1 % (F4)** | 0.00103 | 0.0043 |
| **Potassium sulphate (0:0:50) @ 1 % (F5)** | 0.00033 | 0.0032 |
| **SEm (±)** | 0.000021 | 0.000063 |
| **CD (5%)** | 0.000059 | 0.000182 |
| **Factor – B (Bio-Stimulants)** |  |  |
| **Panchagavya @10 ml/L (B0)** | 0.00065 | 0.0036 |
| **Sagarika @ 3ml/L (B1)** | 0.00072 | 0.0038 |
| **Krishi Shakti @10ml/L (B2)** | 0.00081 | 0.0040 |
| **SEm (±)** | 0.000015 | 0.000045 |
| **CD (5%)** | 0.000042 | 0.000129 |
| **Treatment Combinations** |  |  |
| **T1 (F0 B0)** | 0.00018 | 0.0024 |
| **T2 (F0 B1)** | 0.00025 | 0.0027 |
| **T3(F0 B2)** | 0.00030 | 0.0028 |
| **T4(F1B0)** | 0.00153 | 0.0049 |
| **T5(F1B1)** | 0.001552 | 0.0055 |
| **T6(F1 B2)** | 0.001559 | 0.0060 |
| **T7(F2 B0)** | 0.00040 | 0.0034 |
| **T8(F2 B1)** | 0.00054 | 0.0034 |
| **T9(F2 B2)** | 0.00055 | 0.0035 |
| **T10(F3 B0)** | 0.00067 | 0.0038 |
| **T11(F3 B1)** | 0.00068 | 0.0038 |
| **T12(F3 B2)** | 0.00078 | 0.0040 |
| **T13(F4 B0)** | 0.00080 | 0.0041 |
| **T14(F4 B1)** | 0.00096 | 0.0041 |
| **T15(F4 B2)** | 0.00132 | 0.0046 |
| **T16(F5 B0)** | 0.00031 | 0.0032 |
| **T17(F5 B1)** | 0.00032 | 0.0032 |
| **T18(F5 B2)** | 0.00037 | 0.0033 |
| **SEm (±)** | 0.000036 | 0.000110 |
| **CD (5%)** | 0.000102 | 0.000315 |

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| **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 (F0)** | 0.31 | 0.40 | 0.66 |
| **NPK (19:19:19) @ 1 % (F1)** | 0.49 | 0.73 | 1.31 |
| **Mono potassium phosphate (0:52:34) @ 1 % (F2)** | 0.37 | 0.53 | 1.01 |
| **Potassium nitrate(13:0:45) @ 1 % (F3)** | 0.40 | 0.58 | 1.08 |
| **Urea phosphate (17:44:0) @ 1 % (F4)** | 0.44 | 0.62 | 1.19 |
| **Potassium sulphate (0:0:50) @ 1 % (F5)** | 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 (B0)** | 0.38 | 0.52 | 0.98 |
| **Sagarika @ 3ml/L (B1)** | 0.40 | 0.55 | 1.02 |
| **Krishi Shakti @10ml/L (B2)** | 0.41 | 0.60 | 1.07 |
| **SEm (±)** | 0.003 | 0.010 | 0.010 |
| **CD (5%)** | 0.007 | 0.030 | 0.028 |
| **Treatment Combinations** |  |  |  |
| **T1 (F0 B0)** | 0.27 | 0.37 | 0.60 |
| **T2 (F0 B1)** | 0.32 | 0.41 | 0.61 |
| **T3(F0 B2)** | 0.33 | 0.44 | 0.78 |
| **T4(F1B0)** | 0.48 | 0.64 | 1.30 |
| **T5(F1B1)** | 0.48 | 0.69 | 1.31 |
| **T6(F1 B2)** | 0.51 | 0.87 | 1.33 |
| **T7(F2 B0)** | 0.36 | 0.51 | 0.98 |
| **T8(F2 B1)** | 0.37 | 0.53 | 1.01 |
| **T9(F2 B2)** | 0.38 | 0.55 | 1.05 |
| **T10(F3 B0)** | 0.39 | 0.56 | 1.05 |
| **T11(F3 B1)** | 0.41 | 0.57 | 1.08 |
| **T12(F3 B2)** | 0.42 | 0.60 | 1.11 |
| **T13(F4 B0)** | 0.42 | 0.60 | 1.12 |
| **T14(F4 B1)** | 0.45 | 0.63 | 1.22 |
| **T15(F4 B2)** | 0.45 | 0.63 | 1.23 |
| **T16(F5 B0)** | 0.33 | 0.45 | 0.86 |
| **T17(F5 B1)** | 0.34 | 0.45 | 0.91 |
| **T18(F5 B2)** | 0.35 | 0.50 | 0.92 |
| **SEm (±)** | 0.006 | 0.026 | 0.024 |
| **CD (5%)** | 0.018 | 0.074 | 0.068 |

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| **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 (F0)** | 58.83 | 57.61 | 52.91 |
| **NPK (19:19:19) @ 1 % (F1)** | 65.55 | 64.84 | 60.11 |
| **Mono potassium phosphate (0:52:34) @ 1 % (F2)** | 62.02 | 61.16 | 56.81 |
| **Potassium nitrate(13:0:45) @ 1 % (F3)** | 62.82 | 61.71 | 57.50 |
| **Urea phosphate (17:44:0) @ 1 % (F4)** | 63.38 | 62.59 | 58.42 |
| **Potassium sulphate (0:0:50) @ 1 % (F5)** | 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 (B0)** | 61.47 | 60.83 | 56.15 |
| **Sagarika @ 3ml/L (B1)** | 62.16 | 61.23 | 56.76 |
| **Krishi Shakti @10ml/L (B2)** | 62.59 | 61.87 | 57.41 |
| **SEm (±)** | 0.337 | 0.217 | 0.335 |
| **CD (5%)** | NS | 0.622 | 0.959 |
| **Treatment Combinations** |  |  |  |
| **T1 (F0 B0)** | 56.87 | 56.36 | 52.33 |
| **T2 (F0 B1)** | 59.33 | 57.87 | 52.61 |
| **T3(F0 B2)** | 60.31 | 58.59 | 53.83 |
| **T4(F1B0)** | 64.20 | 64.46 | 58.84 |
| **T5(F1B1)** | 64.23 | 64.89 | 60.63 |
| **T6(F1 B2)** | 65.22 | 65.18 | 60.88 |
| **T7(F2 B0)** | 61.18 | 60.93 | 56.36 |
| **T8(F2 B1)** | 62.42 | 61.14 | 57.02 |
| **T9(F2 B2)** | 62.45 | 61.42 | 57.06 |
| **T10(F3 B0)** | 62.69 | 61.64 | 57.20 |
| **T11(F3 B1)** | 62.87 | 61.66 | 57.32 |
| **T12(F3 B2)** | 62.90 | 61.84 | 57.99 |
| **T13(F4 B0)** | 63.23 | 61.95 | 58.02 |
| **T14(F4 B1)** | 62.35 | 62.06 | 58.53 |
| **T15(F4 B2)** | 63.55 | 63.77 | 58.72 |
| **T16(F5 B0)** | 60.64 | 59.63 | 54.14 |
| **T17(F5 B1)** | 60.76 | 59.75 | 54.43 |
| **T18(F5 B2)** | 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 (F0)** | 140.20 | 168.50 |
| **NPK (19:19:19) @ 1 % (F1)** | 188.10 | 219.77 |
| **Mono potassium phosphate (0:52:34) @ 1 % (F2)** | 165.90 | 195.90 |
| **Potassium nitrate(13:0:45) @ 1 % (F3)** | 169.27 | 199.27 |
| **Urea phosphate (17:44:0) @ 1 % (F4)** | 179.77 | 209.77 |
| **Potassium sulphate (0:0:50) @ 1 % (F5)** | 158.47 | 188.47 |
| **SEm (±)** | 1.169 | 1.707 |
| **CD (5%)** | 3.352 | 4.896 |
| **Factor – B (Bio-Stimulants)** |  |  |
| **Panchagavya @10 ml/L (B0)** | 162.98 | 192.13 |
| **Sagarika @ 3ml/L (B1)** | 167.65 | 197.65 |
| **Krishi Shakti @10ml/L (B2)** | 170.22 | 201.05 |
| **SEm (±)** | 0.826 | 1.207 |
| **CD (5%)** | 2.370 | 3.462 |
| **Treatment Combinations** |  |  |
| **T1 (F0 B0)** | 129.80 | 154.70 |
| **T2 (F0 B1)** | 142.20 | 172.20 |
| **T3(F0 B2)** | 148.60 | 178.60 |
| **T4(F1B0)** | 184.20 | 214.20 |
| **T5(F1B1)** | 188.30 | 218.30 |
| **T6(F1 B2)** | 191.80 | 226.80 |
| **T7(F2 B0)** | 163.90 | 193.90 |
| **T8(F2 B1)** | 166.80 | 196.80 |
| **T9(F2 B2)** | 167.00 | 197.00 |
| **T10(F3 B0)** | 167.50 | 197.50 |
| **T11(F3 B1)** | 169.80 | 199.80 |
| **T12(F3 B2)** | 170.50 | 200.50 |
| **T13(F4 B0)** | 177.90 | 207.90 |
| **T14(F4 B1)** | 179.20 | 209.20 |
| **T15(F4 B2)** | 182.20 | 212.20 |
| **T16(F5 B0)** | 154.60 | 184.60 |
| **T17(F5 B1)** | 159.60 | 189.60 |
| **T18(F5 B2)** | 161.20 | 191.20 |
| **SEm (±)** | 2.024 | 2.956 |
| **CD (5%)** | 5.806 | 8.479 |

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| --- | --- | --- | --- |
| **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 (F0)** | 1.33 | 0.45 | 1.46 |
| **NPK (19:19:19) @ 1 % (F1)** | 1.56 | 0.55 | 1.53 |
| **Mono potassium phosphate (0:52:34) @ 1 % (F2)** | 1.43 | 0.67 | 1.57 |
| **Potassium nitrate(13:0:45) @ 1 % (F3)** | 1.44 | 0.52 | 1.94 |
| **Urea phosphate (17:44:0) @ 1 % (F4)** | 1.48 | 0.58 | 1.50 |
| **Potassium sulphate (0:0:50) @ 1 % (F5)** | 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 (B0)** | 1.42 | 0.52 | 1.58 |
| **Sagarika @ 3ml/L (B1)** | 1.45 | 0.54 | 1.59 |
| **Krishi Shakti @10ml/L (B2)** | 1.45 | 0.57 | 1.65 |
| **SEm (±)** | 0.010 | 0.008 | 0.012 |
| **CD (5%)** | 0.027 | 0.023 | 0.034 |
| **Treatment Combinations** |  |  |  |
| **T1 (F0 B0)** | 1.33 | 0.44 | 1.44 |
| **T2 (F0 B1)** | 1.34 | 0.46 | 1.46 |
| **T3(F0 B2)** | 1.32 | 0.47 | 1.47 |
| **T4(F1B0)** | 1.47 | 0.54 | 1.52 |
| **T5(F1B1)** | 1.59 | 0.55 | 1.52 |
| **T6(F1 B2)** | 1.63 | 0.56 | 1.53 |
| **T7(F2 B0)** | 1.43 | 0.62 | 1.54 |
| **T8(F2 B1)** | 1.43 | 0.64 | 1.55 |
| **T9(F2 B2)** | 1.42 | 0.77 | 1.63 |
| **T10(F3 B0)** | 1.42 | 0.51 | 1.90 |
| **T11(F3 B1)** | 1.45 | 0.52 | 1.93 |
| **T12(F3 B2)** | 1.46 | 0.53 | 1.99 |
| **T13(F4 B0)** | 1.49 | 0.57 | 1.49 |
| **T14(F4 B1)** | 1.48 | 0.58 | 1.50 |
| **T15(F4 B2)** | 1.49 | 0.59 | 1.51 |
| **T16(F5 B0)** | 1.38 | 0.49 | 1.56 |
| **T17(F5 B1)** | 1.39 | 0.51 | 1.57 |
| **T18(F5 B2)** | 1.40 | 0.52 | 1.77 |
| **SEm (±)** | 0.023 | 0.020 | 0.029 |
| **CD (5%)** | 0.067 | 0.057 | 0.083 |

**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 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, phosphorous 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.

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