

## **Enhancing the Growth of Young Satsuma Mandarin Saplings Through Foliar Application of Dry Yeast and Kinetin**

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### **Abstract**

Foliar applications of natural bio stimulants like dry yeast suspension and plant growth regulators like kinetin offer an eco-friendly approach to boosting plant growth, root architecture, and internal chemistry. The objective of this research was to investigate how these two substances influence the growth characteristics and biochemical makeup of young Satsuma mandarin saplings with age 8 months (*Citrus unshiu* Marc.). The trial evaluated a dry yeast suspension (0, 3, 6, and 9 g/L) alongside kinetin treatments (0, 50, and 100 mg/L). The plants were sprayed during the second week of April, May, and June, paused throughout July and August, and completed during the second week of September. Based on our results, the majority of the recorded growth and biochemical traits experienced a significant, dose-dependent increase. Specifically, traits such as sapling height and leaf number increments, leaves area, root dry biomass, and root metrics (taproot length, adventitious root number, and length) were heavily enhanced, as were chlorophyll and shoot nutrient levels. Ultimately, treating the saplings with 9g /L, and kinetin at concentration 100 g/L, kinetin yielded the most pronounced improvements across all measured variables.

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**Key Words:** sustainability, dry yeast, suspension, kinetin, satsuma mandarin.

### **Introduction**

The Satsuma (*Citrus unshiu* Marc.) is a notable member of the Rutaceae family, highly valued for its exceptional flavor and easily removable rind. Likely originating in East Asia as a hybrid of the pumelo and mandarin, this seedless fruit has a rich history; its cultivation began in Japan's Satsuma Prefecture nearly a thousand years ago, eventually making its way to citrus-growing regions in Florida and California [21, 23, 28]. Because this evergreen tree tolerates both high temperatures and severe cold, it adapts effortlessly to diverse environmental

conditions. This climate resilience, paired with its robust productivity, positions the Satsuma as an ideal candidate for sustainable farming [19, 18, 24]. Recent research highlights on bio stimulant, like active dry yeast (*Saccharomyces cerevisiae*) as a promising, eco-friendly bio stimulant for sustainable farming, capable of significantly boosting vegetative growth and crop productivity. The efficacy of yeast stems from its rich nutritional profile, which includes essential macro- and micronutrients, amino acids, B vitamins, and natural cytokinin's [31, 25, 29]. Its high cytokinin content accelerates cell division, thereby facilitating

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macromolecule synthesis and chlorophyll production. Furthermore, yeast-derived CO<sub>2</sub> release enhances photosynthetic efficiency, ultimately driving biomass accumulation [27, 8]. When administered as a foliar spray, yeast delivers nutrients directly to the plant, ensuring a steady supply of elements while bypassing the traditional issues of nutrient fixation and deposition within the soil [31, 29, 6]. The positive impact of active dry yeast suspensions on plant development has been documented across various species; for instance, it has been shown to optimize the performance of 'Minneola' tangelo trees [15] and enhance the chemical composition of lemon seedlings [1]. Maximizing biomass accumulation and controlling plant morphogenesis remain primary targets of current agricultural research involving plant growth regulators [12]. A key player in this field is kinetin [37]. Although it was first extracted and purified from non-plant sources, it is now known to occur naturally within plants through specific DNA modifications [11]. Belonging to the adenine

### **Materials and Methods**

From April to December 2025, an experiment was carried out in the lath house at the University of Anbar College of Agriculture (Department of Horticulture and Landscape Gardening) to investigate how foliar application with bio stimulant, viz., dry yeast suspension and kinetin influence the growth performance and chemical content of Satsuma mandarin saplings. The saplings were acquired on March 20, 2025, from a private nursery situated in the Al-Krayat region north of Baghdad. A uniform group of 108 saplings was selected for the study. Initially grown in (18cm× 16cm), and they were subsequently transplanted into larger pots (33cm× 24cm) filled with (3:1) (v/v) mixture of soil and peat moss. General crop management practices, such as hand-weeding the

group of the cytokinin family, kinetin plays a comprehensive role in directing plant physiology by promoting cell division, shoot outgrowth, and apical meristem activity [38]. Furthermore, it directs the movement of vital minerals and nutrients to target tissues, stimulates chloroplast development alongside chlorophyll synthesis, delays leaf aging, and regulates overall plant appearance [22]. Previous literature supports these applications; notably, foliar growth regulators have been shown to cooperatively enhance the growth of 'Cleopatra' mandarin seedlings [36], and kinetin sprays have successfully boosted the development of "Sourani" olive seedlings [4]. Building on these insights, the primary objective of this research is to investigate how combining dry yeast suspension and kinetin via foliar feeding can enhance vegetative traits, root architecture, and chemical content to build stronger sapling structures more rapidly, while also establishing the optimal application dosages.

containers, were carried out regularly. Crop protection was managed by spraying chemical pesticides immediately upon detecting any insect or mite activity. To control aphids, cutworms, and the citrus leaf miner, the saplings were treated with abamectin 1.8% at (1ml/ L) and alpha-cypermethrin 10% at (1ml/ L) on April 6, 2025. This protection program continued biweekly during May and June, was paused throughout July and August, and was reinstated during September and October. Plant nutrition was maintained using a balanced (20:20:20) fertilizer. Representative samples of the soil matrix were also collected and analyzed to document its physical and chemical properties (Table 1).

**Table 1.** Soil Analysis(Physical and Chemical properties)

**Clay loam texture**

| <b>pH</b> | <b>EC</b><br>(1:1)<br>ds.m <sup>-1</sup> | <b>CEC</b><br>C.mol.l <sup>-1</sup> | <b>O.M</b><br>g kg <sup>-1</sup><br>soil | <b>Sand</b><br>g kg <sup>-1</sup><br>soil | <b>Loam</b><br>g.kg <sup>-1</sup><br>soil | <b>Clay</b><br>g.kg <sup>-1</sup><br>soil | <b>N</b><br>mg<br>kg <sup>-1</sup> | <b>P</b><br>mg<br>kg <sup>-1</sup> | <b>K</b><br>mg kg <sup>-1</sup> | <b>CaCO<sub>3</sub></b><br>g .kg <sup>-1</sup> |
|-----------|------------------------------------------|-------------------------------------|------------------------------------------|-------------------------------------------|-------------------------------------------|-------------------------------------------|------------------------------------|------------------------------------|---------------------------------|------------------------------------------------|
| 7.1       | 2.36                                     | 26.33                               | 12.0                                     | 723                                       | 60                                        | 217                                       | 59.6<br>6                          | 13.8                               | 216.8                           | 176.3                                          |

This study evaluated two experimental factors. Factor one involved foliar spraying of a dry yeast suspension at four distinct concentrations (0, 3, 6, and 9 g L<sup>-1</sup>) coded as Y<sub>0</sub>, Y<sub>1</sub>, Y<sub>2</sub>, and Y<sub>3</sub> (Table 2) for full composition details based on (22). The yeast suspension was prepared by dissolving bread yeast and sucrose in warm water at a 1:1 weight-to-weight (w/w) ratio. In accordance with [2], this mixture was incubated for 24 hours to ensure adequate cell activation and growth prior to application. Factor two consisted of kinetin (99%) applied at 0,50, and 100 mg L<sup>-1</sup> (represented by K<sub>0</sub>, K<sub>1</sub>, and K<sub>2</sub>, respectively). To prepare this solution, kinetin was initially dissolved in 25 mL of 95% ethanol and subsequently brought to a 1 L volume with

distilled water. The plants were sprayed early in the morning during the second week of April, May, and June, paused throughout July and August, and completed during the second week of September. Sprays were applied using a 10 L capacity sprayer containing 0.1% Tween 20 as a wetting surfactant. A Randomized Complete Block Design (RCBD) with three replications was employed for the experimental layout, utilizing 3 saplings per experimental unit. Data analysis was conducted via a statistical software package. Mean separations and statistical differences were evaluated at a 5% probability level ( $P \leq 0.05$ ) in accordance with [5]. To assess the treatments, the following growth and chemical indicators were measured:

**Table 2.**Chemical analysis of yeast extract used, according to Vi-cor® company, South Caroline Ave, Mason City, U.S.A.

| <b>Amino acids (%)</b> |      | <b>Vitamins (mg/100g dry weight)</b> | <b>Minerals</b>      |
|------------------------|------|--------------------------------------|----------------------|
| Alanine                | 1.69 | Vit.B1<br>23.33                      | Nitrogen<br>6.88%    |
| Arginine               | 1.49 | Vit.B2<br>21.04                      | Phosphorus 0.66<br>% |
| Aspartic Acid          | 2.32 | Vit.B6<br>20.67                      | Potassium<br>0.95    |
| Cystine                | 0.63 | Vit.B12<br>19.17                     | Magnesium<br>0.19    |
| Glutamic Acid          | 3.76 | Thiamine<br>23.21                    | Calcium<br>0.17      |
| Glycine                | 1.45 | Riboflavin<br>27.29                  | Sulfur<br>0.48       |

|               |      |                         |      |           |     |
|---------------|------|-------------------------|------|-----------|-----|
| Histidine     | 0.71 | Insitol                 |      | Iron      | 107 |
|               |      | 20.43                   |      | ppm       |     |
| Isoleucine    | 0.85 | Biotin                  |      | Zinc      | 77  |
|               |      | 20.04                   |      | ppm       |     |
| Leucine       | 1.91 | Nicotinic               | acid | Copper    |     |
|               |      | 73.92                   |      | 5ppm      |     |
| Lysine        | 1.13 | Panthothenic            | acid | Manganese |     |
|               |      | 38.43                   |      | 13ppm     |     |
| Phenylalanine | 1.18 | P amino benzoic         | acid |           |     |
|               |      | 29.49                   |      |           |     |
| Proline       | 1.29 | Folic                   | acid |           |     |
|               |      | 26.22                   |      |           |     |
| Serine        | 1.98 | Pyridoxine              |      |           |     |
|               |      | 22.09                   |      |           |     |
| Threonine     | 1.54 | Growth Regulators (ppm) |      |           |     |
| Tryptophan    | 0.25 | Adenine                 |      |           |     |
|               |      | 31                      |      |           |     |
| Tyrosine      | 0.99 | Betaines                |      |           |     |
|               |      | 56                      |      |           |     |
| Valine        | 1.4  |                         |      |           |     |
| Methionine    | 0.4  |                         |      |           |     |

**Increment in sapling height (cm):** The seedling height was measured at the beginning of the experiment in April 2025 and another reading was taken upon completion of the experiment at the beginning of December 2025. Based on the difference between the two readings, the rate of increase in seedling height was calculated.

**Increment in leaf number (leaf sapling<sup>-1</sup>):** The number of leaves was counted in April 2025 (the beginning of the experiment), and a final reading was taken in November 2025. The difference between the two readings was calculated to determine the rate of increase in the number of leaves.

**Leaves area (dm<sup>2</sup>):** In November 2025, at the fifth-eighth node from the top of the branches, the area of 8 leaves was taken. By dividing the total by 8, the average area of a single leaf is obtained, which was measured by taking the maximum length and maximum width of the leaf, as follows: Leaf area (cm<sup>2</sup>)= length ×width × 2/3, The leaf area of the sapling (cm<sup>2</sup>) = the

number of leaves per sapling × the average area of one leaf (cm<sup>2</sup>). Then the value of the leaf area (cm<sup>2</sup>) was converted to (dm<sup>2</sup>).

**Tap root length (cm) increment:** At the end of the experiment in December 2025, one sapling was harvested from each replicate. Its root system was carefully washed with water, cleaned, and blotted dry. To determine the overall rate of root length increase, the initial root length measured at the start of the study was subtracted from the final length.

**Adventitious roots number (root. Sapling<sup>-1</sup>)increment:** The root systems were washed with water, and the number of lateral roots was recorded. To determine the rate of increase over the course of the study, the initial root count taken at the beginning of the experiment was subtracted from the final count.

**Adventitious roots length (cm) increment:** It was quantified from the point of attachment to the root tip. The difference between the average root length at the beginning and end of the experiment was calculated.

**Roots dry mass (g):** It was determined after washing the roots and removing the soil, then drying them in an oven to dry until constant mass.

**Chlorophyll (mg per 100 g fresh weight):** The method according to [14] was followed to estimate the chlorophyll content, with the extract samples being read using a spectrophotometer at wavelength of 663 and 645 nm. Based on the obtained readings, the following relation was used : Chlorophyll (mg/L<sup>-1</sup>) = 20.2 D (645) + 8.02 D

(663). **Shoot carbohydrate (%), Shoot nitrogen (%), and C/N ratio:** Chemical analyses of the main branches were conducted at the end of the study in December 2025. Total carbohydrate levels were estimated using the method established by [13], while shoot nitrogen content was evaluated according to the procedures of [9]. To determine the branch C/N ratio, the percentage of total carbohydrates was divided by the corresponding nitrogen percentage.

## Results and Discussion

**Increment in sapling height (cm):** The results in Table (3) showed a significant increase for all concentrations of dry yeast and kinetin and their interaction in increasing sapling height; Y<sub>3</sub>(9 g /L ), and K<sub>2</sub> (100 mg /L) recorded the maximum averages of (32.46 and 32.52 cm ) respectively, compared to Y<sub>0</sub> and K<sub>0</sub>, which gave (27.21 and 28.38 cm ) respectively. Similarly, the interaction treatment Y<sub>2</sub>K<sub>2</sub> was distinguished by the highest average of all at 35.09 cm, compared to control.

**Increment in leaf number (leaf sapling<sup>-1</sup>):** The outputs in Table 3 demonstrated a significant effect of dry yeast, kinetin, and their interaction on increasing leaf number. Y<sub>3</sub> and K<sub>2</sub> achieved the

highest value (79.56 and 75.86 leaf sapling<sup>-1</sup>), respectively, compared to Y<sub>0</sub> and K<sub>0</sub>, which gave (49.69 and 55.75 leaf sapling<sup>-1</sup>), respectively. In the same context, the interaction treatment Y<sub>3</sub>K<sub>1</sub> gave the maximum value, reaching 88.77 leaf sapling<sup>-1</sup>), compared to the control.

**Leaves area (dm<sup>2</sup>):** The results in Table 3 showed a significant increase in the leaves area due to treatment with dry yeast and kinetin. Y<sub>2</sub> and K<sub>1</sub> resulted in area of 25.98 and 22.61dm<sup>2</sup>, respectively. Further confirming this superiority, Y<sub>2</sub>K<sub>1</sub> achieved the highest dry mass of 29.79 dm<sup>2</sup>, compared to 10.83dm<sup>2</sup> for the control treatment.

**Table 3.** Effect of foliar application with dry yeast suspension, kinetin, and their interaction on some growth characteristics.

| Kinetin<br>(K)                                         | Dry Yeast (Y)                    |                                       |                                      |                                      | Mean  |
|--------------------------------------------------------|----------------------------------|---------------------------------------|--------------------------------------|--------------------------------------|-------|
|                                                        | Y <sub>0</sub><br>control        | Y <sub>1</sub> = 3 g. L <sup>-1</sup> | Y <sub>2</sub> = 6 g.L <sup>-1</sup> | Y <sub>3</sub> =9 g. L <sup>-1</sup> |       |
|                                                        | Increment in sapling height (cm) |                                       |                                      |                                      |       |
| K <sub>0</sub> = control                               | 26.03                            | 26.71                                 | 28.89                                | 31.91                                | 28.38 |
| K <sub>1</sub> = 50 mg.L <sup>-1</sup>                 | 26.70                            | 28.49                                 | 28.57                                | 31.17                                | 28.73 |
| K <sub>2</sub> = 100 mg.L <sup>-1</sup>                | 28.91                            | 31.76                                 | 35.09                                | 34.30                                | 32.52 |
| Mean                                                   | 27.21                            | 28.99                                 | 30.85                                | 32.46                                |       |
| L.S.D 0.05                                             | Y                                | K                                     | Y×K                                  |                                      |       |
|                                                        | 1.06                             | 0.92                                  | 1.84                                 |                                      |       |
| Increment in leaf number (leaf sapling <sup>-1</sup> ) |                                  |                                       |                                      |                                      |       |
| K <sub>0</sub> = control                               | 38.57                            | 56.57                                 | 62.13                                | 65.73                                | 55.75 |
| K <sub>1</sub> = 50 mg.L <sup>-1</sup>                 | 53.93                            | 72.37                                 | 81.93                                | 88.77                                | 74.25 |

|                                         |       |       |       |       |       |
|-----------------------------------------|-------|-------|-------|-------|-------|
| K <sub>2</sub> = 100 mg.L <sup>-1</sup> | 56.57 | 77.37 | 85.33 | 84.17 | 75.86 |
| Mean                                    | 49.69 | 68.77 | 76.47 | 79.56 |       |
| L.S.D 0.05                              | Y     | K     | Y×K   |       |       |
|                                         | 2.04  | 1.76  | 3.53  |       |       |
| Leaves area (dm <sup>2</sup> )          |       |       |       |       |       |
| K <sub>0</sub> = control                | 10.83 | 16.99 | 19.96 | 22.05 | 17.46 |
| K <sub>1</sub> = 50 mg.L <sup>-1</sup>  | 15.77 | 22.34 | 28.20 | 24.11 | 22.61 |
| K <sub>2</sub> = 100 mg.L <sup>-1</sup> | 17.02 | 19.91 | 29.79 | 22.29 | 22.25 |
| Mean                                    | 14.54 | 19.75 | 25.98 | 22.82 |       |
| L.S.D 0.05                              | Y     | K     | Y×K   |       |       |
|                                         | 0.68  | 0.59  | 1.18  |       |       |

LSD (  $P \leq 0.05$  ) = Least significant difference

**Taproot length (cm) increment:** Data in Table 4 revealed that the application of dry yeast suspension and kinetin significantly affected taproot length. Y<sub>3</sub> and K<sub>2</sub> achieved the highest length (19.63 and 18.67 cm, respectively) compared to Y<sub>0</sub> and K<sub>0</sub>, which gave (11.44 and 14.61 cm, respectively). On the other hand, the interaction between treatments showed a remarkable effect; Y<sub>3</sub>K<sub>2</sub> gave the highest length (21.60 cm), in comparison to control (10.55 cm).

**Adventitious roots number (root. Sapling<sup>-1</sup>) increment:** As shown in Table 4, foliar application of dry yeast suspension and kinetin at concentrations Y<sub>3</sub> and K<sub>2</sub> significantly increased the adventitious root number, which recorded (10.56 and 10.00 root sapling<sup>-1</sup>), whereas the lowest number was noticed at Y<sub>0</sub> and K<sub>0</sub> (7.22 and 7.25 root sapling<sup>-1</sup>). In the same context, the interaction treatment, Y<sub>3</sub>K<sub>2</sub>, showed a noticeable effect, reaching 11.67 root sapling<sup>-1</sup>, compared to the control.

**Adventitious root length (cm) increment:** Data in Table 4 illustrates that the adventitious root length was significantly enhanced by both treatments, especially Y<sub>3</sub> and K<sub>2</sub>, which recorded the highest length (15.22 and 15.00 cm), compared to Y<sub>0</sub> and K<sub>0</sub> which gave the minimum value. The interaction between treatments demonstrated a strong synergistic effect; Y<sub>1</sub>K<sub>2</sub> achieved the maximum length, reaching 17.33 cm, compared to the control.

**Root dry mass (g):** Data in Table 4 indicated that spraying satsuma mandarin saplings by activated dry yeast and kinetin resulted in a significant increase in root dry

mass. Treatment Y<sub>3</sub> and K<sub>2</sub> was the most effective, achieving (32.68 and 31.67 g respectively). Similarly, the dual interaction produced a highly significant response with the Y<sub>3</sub>K<sub>2</sub> interaction achieving the highest dry mass of 35.27 g compared to the control.

**Table 4.** Effect of foliar application with dry yeast suspension, kinetin, and their interaction on root growth and root system dry mass.

| Kinetin<br>(K)                                                    | Dry Yeast (Y)             |                                       |                                      |                                      | Mean  |
|-------------------------------------------------------------------|---------------------------|---------------------------------------|--------------------------------------|--------------------------------------|-------|
|                                                                   | Y <sub>0</sub><br>control | Y <sub>1</sub> = 3 g. L <sup>-1</sup> | Y <sub>2</sub> = 6 g.L <sup>-1</sup> | Y <sub>3</sub> =9 g. L <sup>-1</sup> |       |
| Tap root length (cm)increment                                     |                           |                                       |                                      |                                      |       |
| K <sub>0</sub> = control                                          | 10.55                     | 14.66                                 | 15.45                                | 17.78                                | 14.61 |
| K <sub>1</sub> = 50 mg.L <sup>-1</sup>                            | 10.93                     | 16.06                                 | 15.81                                | 19.51                                | 15.58 |
| K <sub>2</sub> = 100 mg.L <sup>-1</sup>                           | 12.84                     | 19.39                                 | 20.87                                | 21.60                                | 18.67 |
| Mean                                                              | 11.44                     | 16.70                                 | 17.38                                | 19.63                                |       |
| L.S.D 0.05                                                        | Y                         | K                                     | Y×K                                  |                                      |       |
|                                                                   | 0.50                      | 0.43                                  | 0.86                                 |                                      |       |
| Adventitious roots number (root. Sapling <sup>-1</sup> )increment |                           |                                       |                                      |                                      |       |
| K <sub>0</sub> = control                                          | 5.67                      | 6.67                                  | 7.00                                 | 9.67                                 | 7.25  |
| K <sub>1</sub> = 50 mg.L <sup>-1</sup>                            | 6.67                      | 9.00                                  | 9.67                                 | 10.33                                | 8.92  |
| K <sub>2</sub> = 100 mg.L <sup>-1</sup>                           | 9.33                      | 8.67                                  | 10.33                                | 11.67                                | 10.00 |
| Mean                                                              | 7.22                      | 8.11                                  | 9.00                                 | 10.56                                |       |
| L.S.D 0.05                                                        | Y                         | K                                     | Y×K                                  |                                      |       |
|                                                                   | 0.74                      | 0.42                                  | 0.98                                 |                                      |       |
| Adventitious roots length (cm)increment                           |                           |                                       |                                      |                                      |       |
| K <sub>0</sub> = control                                          | 7.34                      | 9.67                                  | 12.33                                | 13.00                                | 10.59 |
| K <sub>1</sub> = 50 mg.L <sup>-1</sup>                            | 10.33                     | 12.00                                 | 12.87                                | 17.00                                | 13.05 |
| K <sub>2</sub> = 100 mg.L <sup>-1</sup>                           | 13.17                     | 17.33                                 | 13.83                                | 15.67                                | 15.00 |
| Mean                                                              | 10.28                     | 13.00                                 | 13.01                                | 15.22                                |       |
| L.S.D 0.05                                                        | Y                         | K                                     | Y×K                                  |                                      |       |
|                                                                   | 0.85                      | 0.74                                  | 1.48                                 |                                      |       |
| Root dry mass (g)                                                 |                           |                                       |                                      |                                      |       |
| K <sub>0</sub> = control                                          | 19.34                     | 22.98                                 | 29.23                                | 29.53                                | 25.27 |
| K <sub>1</sub> = 50 mg.L <sup>-1</sup>                            | 26.30                     | 28.53                                 | 32.43                                | 33.23                                | 30.12 |
| K <sub>2</sub> = 100 mg.L <sup>-1</sup>                           | 27.63                     | 31.10                                 | 32.67                                | 35.27                                | 31.67 |
| Mean                                                              | 24.43                     | 27.54                                 | 31.44                                | 32.68                                |       |
| L.S.D 0.05                                                        | Y                         | K                                     | Y×K                                  |                                      |       |
|                                                                   | 1.03                      | 0.89                                  | 1.78                                 |                                      |       |

LSD (  $P \leq 0.05$ ) = Least significant difference

**Chlorophyll(mg per 100 g fresh weight)**  
According to the data illustrated in Table 5,

spraying with activated dry yeast and kinetin and their combination significantly

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increased chlorophyll content. Treatment Y<sub>3</sub> and K<sub>2</sub> achieved the highest content, which recorded (232.14 and 226.28 mg per 100 g fresh weight, respectively), with an increase of (11.88 % and 6.46%, respectively), compared to Y<sub>0</sub> and K<sub>0</sub>. Likewise, the interaction between treatments showed a significant effect; the Y<sub>3</sub>K<sub>2</sub> recorded the highest value at 245.78 mg per 100 g fresh weight compared to the control. **Shoot carbohydrate (%):** The statistical analysis results in Table 5 show that spraying saplings with activated dry yeast and kinetin indicating a superior and proportional increase in saccharide content. Treatments Y<sub>3</sub>, K<sub>2</sub>, and their interaction Y<sub>3</sub>K<sub>2</sub> achieved the highest value, reaching 11.04 %, 10.90 %, and 11.88% for each treatment, respectively, compared to the Y<sub>0</sub>, K<sub>0</sub>, and the control treatment.

**Shoot nitrogen (%):** The statistical analysis shown in Table 5 that spraying satsuma mandarin saplings with dry yeast suspension, kinetin, and their combined application significantly increased the nitrogen content. Treatments Y<sub>3</sub>, K<sub>2</sub>, and their interaction showed a significantly higher increase of 0.621%, 0.578%, and 0.654%, while Y<sub>0</sub>, K<sub>0</sub>, and the control treatment gave the lowest percentage of nitrogen content.

**C/N Ratio:** According to the data in Table 5, feeding with activated dry yeast and kinetin and the crosstalk between them resulted in a significant increase in the C/N ratio. Treatments Y<sub>3</sub> and K<sub>2</sub>, and their interaction achieved the highest values, reaching 17.80, 18.90, and 20.54 for each treatment, respectively, compared to Y<sub>0</sub>, K<sub>0</sub>, and the control treatment, which gave 16.90, 15.25, and 13.75 respectively.

**Table 5.** Effect of foliar application with dry yeast suspension, kinetin, and their interaction on chemical content and C/N Ratio

| Kinetin<br>(K)                          | Dry Yeast (Y)             |                                       |                                      |                                      | Mean   |
|-----------------------------------------|---------------------------|---------------------------------------|--------------------------------------|--------------------------------------|--------|
|                                         | Y <sub>0</sub><br>control | Y <sub>1</sub> = 3 g. L <sup>-1</sup> | Y <sub>2</sub> = 6 g.L <sup>-1</sup> | Y <sub>3</sub> =9 g. L <sup>-1</sup> |        |
| Chlorophyll (mg per 100 g fresh weight) |                           |                                       |                                      |                                      |        |
| K <sub>0</sub> = control                | 204.44                    | 209.46                                | 211.47                               | 224.80                               | 212.54 |
| K <sub>1</sub> = 50 mg.L <sup>-1</sup>  | 207.42                    | 211.43                                | 216.10                               | 225.83                               | 215.20 |
| K <sub>2</sub> = 100 mg.L <sup>-1</sup> | 210.60                    | 229.03                                | 219.69                               | 245.78                               | 226.28 |
| Mean                                    | 207.49                    | 216.64                                | 215.75                               | 232.14                               |        |
| L.S.D 0.05                              | Y                         | K                                     | Y×K                                  |                                      |        |
|                                         | 2.40                      | 2.08                                  | 4.16                                 |                                      |        |
| Shoot carbohydrate (%)                  |                           |                                       |                                      |                                      |        |
| K <sub>0</sub> = control                | 7.03                      | 7.56                                  | 8.35                                 | 10.45                                | 8.35   |
| K <sub>1</sub> = 50 mg.L <sup>-1</sup>  | 7.80                      | 8.45                                  | 9.03                                 | 10.80                                | 9.02   |
| K <sub>2</sub> = 100 mg.L <sup>-1</sup> | 9.91                      | 10.62                                 | 11.18                                | 11.88                                | 10.90  |
| Mean                                    | 8.25                      | 8.87                                  | 9.52                                 | 11.04                                |        |
| L.S.D 0.05                              | Y                         | K                                     | Y×K                                  |                                      |        |

|                                         | 0.25  | 0.22  | 0.44  |       |       |
|-----------------------------------------|-------|-------|-------|-------|-------|
| <b>Shoot nitrogen (%)</b>               |       |       |       |       |       |
| K <sub>0</sub> = control                | 0.459 | 0.549 | 0.595 | 0.585 | 0.547 |
| K <sub>1</sub> = 50 mg.L <sup>-1</sup>  | 0.532 | 0.522 | 0.613 | 0.624 | 0.573 |
| K <sub>2</sub> = 100 mg.L <sup>-1</sup> | 0.541 | 0.573 | 0.544 | 0.654 | 0.578 |
| Mean                                    | 0.511 | 0.548 | 0.584 | 0.621 |       |
| L.S.D 0.05                              | Y     | K     | Y×K   |       |       |
|                                         | 0.017 | 0.015 | 0.030 |       |       |
| <b>C / N Ratio</b>                      |       |       |       |       |       |
| K <sub>0</sub> = control                | 15.32 | 13.75 | 14.04 | 17.87 | 15.25 |
| K <sub>1</sub> = 50 mg.L <sup>-1</sup>  | 14.65 | 16.22 | 14.71 | 17.31 | 15.72 |
| K <sub>2</sub> = 100 mg.L <sup>-1</sup> | 18.31 | 18.54 | 20.54 | 18.21 | 18.90 |
| Mean                                    | 16.09 | 16.17 | 16.43 | 17.80 |       |
|                                         | Y     | K     | Y×K   |       |       |
|                                         | 0.69  | 0.59  | 1.19  |       |       |

LSD (  $P \leq 0.05$  ) = Least significant difference

The role of bio stimulant, such as, dry yeast suspension in enhancing growth parameters is possibly due to the critical importance played by the components of dry yeast suspension (Table 2) due to its amino acid content, which influences the synthesis of secondary compounds, activates the plant's enzyme system, particularly the oxidation-reduction system, increases cell division and elongation, and enhances the efficiency of carbon metabolism and the synthesis of carbohydrates and proteins, thus contributing to increased vegetative growth [17, 33]. Alternatively, it may be attributed to its significant role in stimulating physiological and biochemical processes. Amino acids are the building blocks of proteins, stimulate photosynthesis and carbohydrate synthesis, and contribute to the formation and activation of several enzymes and coenzymes, ultimately leading to improved plant growth [10]. Furthermore, they act as a bio stimulant, positively impacting plant growth and effectively mitigating the effects of environmental stresses [20]. Nutrients, including nitrogen, potassium, and phosphorus, also play an essential role in the

biochemical pathway. Photosynthesis, as nitrogen is involved in the composition of cytochromes necessary for photosynthesis and respiration [35]. Roots are a fundamental pillar in plant life, playing a pivotal role in absorbing nutrients and providing the necessary structural support [32, 34]. Looking at the results in Table (4), we observe a significant positive effect of treating samplings with a dry yeast suspension and the growth regulator kinetin on root growth indicators, which included the rate of increase in taproot length, the rate of increase in the number of adventitious roots, the rate of increase in adventitious root length, and the dry root mass. This may be attributed to the ability of these substances to stimulate the overall performance of the vegetative system, which necessarily leads to enhancing root characteristics as a direct result. According to [16] activating the vegetative system leads to an increase in the efficiency of photosynthesis, and thus the transfer of excess carbohydrates and other manufactured materials from the leaves to the roots, which supports their growth and spread, thus increasing dry matter.

These results are consistent with what many scientific studies in this field have concluded, most notably[7, 30] when explore the impact of activated yeast on one-year-old sour orange seedlings,[2] when studying the effect of

## Conclusion

Understanding the mechanism of dry yeast and kinetin applications is vital given that yeast provides a potent mix of amino acids, proteins, B vitamins, nucleic acids, lipids, and essential nutrients (N, P, K, Ca, Mg, Fe, Zn). Foliar feeding bypasses soil limitations in arid or poor conditions, ensuring rapid plant absorption. This study evaluated this sustainable approach on Satsuma mandarin saplings. The results indicate that combining

spraying with a dry yeast suspension on some growth characteristics of citrus rootstock seedlings, and [4, 26] when studying the effect of spraying with kinetin on some growth characteristics of olive seedlings.

(9 g/L) activated dry yeast with (100 mg/L)kinetin maximized all evaluated parameters. This optimal treatment interaction significantly enhanced sapling height, leaf number, leaf area, chlorophyll levels, carbohydrate and nitrogen accumulation, the C/N ratio, and root metrics such as primary length, adventitious root development, and dry biomass.

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