Plant Sci. Arc.
Plant Science Archives
An International Journal of Plant Biology

Original Research Article
ISSN 2518-6965
Journal Homepage: www.plantarc.com

Response of Passion Fruit (*Passiflora edulis* Sims) to applying and foliar spraying organic fertilizers and its effect on the vegetative growth (Case study)

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Citation: Zainab Turky AL-Taee (2026). Response of Passion Fruit (*Passiflora edulis* Sims) to applying and foliar spraying organic fertilizers and its effect on the vegetative growth (Case study). *Plant Science Archives.*
DOI: https://doi.org/10.51470/PSA.2026.11.1.42

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Received 13 October 2025 | Revised 14 November 2025 | Accepted 10 December 2025 | Available Online 14 January 2026

ABSTRACT

Passion fruit and its by-products (leaves, peels, seeds) have economic significance, fertilization should be provided to enable the activity of metabolic processes and maximize the growth The objective of this study was to evaluate the effect of varying amounts of soil-applied organic fertilizer and foliar use of an organic extract on the vegetative growth of passion fruit (Passiflora edulis) seedlings that were nine months old. The experiment was completed at the horticulture nursery of the Directorate of Agriculture in the Babylon Governorate in Iraq for the period from 1st March to mid-November 2022. The nursery conditions were put in plastic pots where the seedlings grew. The experimental design was a randomized complete block design (R.C.B.D.) consisting of three replicates and two factors of the experiment. Factor 1 was organic fertilizer using date palm waste, which was applied to the soil at three rates, namely 0, 30, and 40 g per seedling. Factor 2 comprised foliar spraying using X-Humate 85% extract at the concentrations of 0 and 10ml L^{-1}. The statistical method of analyzing data was the Least Significant Difference (L.S.D.) test at a 5 percent significance level. The results show that the addition of 40 g of palm waste per seedling was very high in enhancing all the parameters of vegetative growth, which were plant height, plant stem diameter, number of branches and leaves, plant leaf area, chlorophyll content of leaves, and carbohydrate. There were also significant improvements in these traits upon foliar application of X-Humate 85% at 10 ml L^{-1} relative to the untreated control. The combination of the work of soil fertilization and foliar spraying led to high vegetative growth in all the characteristics that were measured.

Keywords: *Passion fruit, organic fertilizer, nutrition (soil and foliar), vegetative growth.*

INTRODUCTION

Passiflora edulis, or passion fruit, is a perennial and evergreen belonging to Passifloraceae with about 500 species. Brazil is its origin, where it has been grown in tropical and subtropical parts of Africa and Asia. Passion fruit is considered to be high in minerals, vitamins, and bioactive compounds that find use in the cosmetic and pharmaceutical sectors[1]. There are two major cultivars commonly grown of passion fruit, the purple *P. edulis* f. *edulis* Sims and the yellow *P. edulis* f. *flavicarpa* Degener {2].

The sapling quality is of importanceto determine future productivity, particularly that of the yellow cultivar, which is usually evaluated under the soil conditions with natural organic inputs [3]. Since passion fruit and its by-products (leaves, peels, seeds) have economic significance, fertilization should be provided to enable the activity of metabolic processes and maximize the growth [4&5]. Due to environmental and economic issues related to chemical fertilizers, interest in organic plant remains, such as palm frond remains, can be used alternatively to chemical fertilizers. Generally, plant material compostare affordable, biodegradable, and increases soil fertility and is cost-effective [6,7&8].

Fruit trees, including pomegranate saplings, can always be grow at the highest when responding to the synergistic effect of the soil-applied and foliar organic fertilizers {9,10]. The recent research has proven the efficacy of organic fertilization in enhancing plant growth in passion fruit seedlings [11]. According to the research conducted by [12], the foliar use of liquid organic fertilizer at 15 ml L^{-1} had a significant impact on the height of the plants, the number of leaves, the number of branches, and the leaf area. On the same note, [13] determined that the height, stem diameter, and leaf production of seedlings were significantly improved by applying organic fertilizer and medium of composted fruit plant residues, e.g., banana peels, cupuacu bark, almond, chestnut, and cashew nut shells, in equal proportions--providing an alternative to traditional media. As shown by {14], soil amendment with the 0.5 t ha^{-1} organic fertilizer had a significant positive effect on seedling vigor, plant height, stem thickness, branching, leaf development, leaf area, and nutrient uptake. An evident study showed that growth characteristics of tropical passion fruit saplings were greatly enhanced by foliar fertilization with 10 ml L^{-1} [15](Al-Taee et al., 2025).

[16] Mahmoud and Hadi (2023) applied the same results to apple seedlings and demonstrated that the addition of palm frond waste at 1 kg $seedling^{-1}$ into the soil had a beneficial effect on both the vegetative and biochemical growth characteristics. As pointed out by [17]Bocol et al. (2020), the incorporation of rice bran in soil had the advantage of encouraging vegetative development in passion fruit seedlings in addition to enhancing soil physicochemical characteristics. The increase in popularity of liquid organic fertilizers can be explained by the presence of humic and fulvic acids, amino acids, and other bioactive compounds in them. These are low-cost inputs that are green and help in improving crop quality and ecological sustainability [18,19]. [20] highlighted that organic extracts are useful nutritional supplements to the use of chemical fertilizers, which is in line with the principles of the sustainability of agriculture and in favor of the healthy production of fruit crops.

The study will seek to prepare organic growth mediums that will suit the growth of passion fruits in the agro-ecological environment of Iraq, bearing in mind that the plant is tropical in origin and also sensitive to organic nutrients.

MATERIALS AND METHODS

The current experiment was done under a canopy made of wood in the horticulture nursery of the Directorate of Agriculture in Babylon Governorate, Iraq, between March 1 and November 15, 2022. It aimed at determining how passion fruit seedlings responded to soil amendment with organic fertilizer made of palm frond waste and applied through the leaf with X-Humate 85% organic extract. A factorial experiment was implemented following a Randomized Complete Block Design (R.C.B.D.) with three replications. The treatments included soil application with organic fertilizer as palm frond compost, applied at 0, 30, and 40 g sapling^{-1} all with or without foliar spray with X-Humate 85% at 10 ml L^{-1}. The seedlings were nine months old. Tables (1,2) showed the components of the treatments used in the study: organic fertilizer and organic fertilizer extract (X - Humate 85%). Palm frond waste was incorporated into the potting substrate upon transplanting the seedlings from polyethylene bags into pots on March 1, 2022, according to the designated application rates. Foliar application of the organic extract (X- Humate 85%) was administered in five separate intervals: March 15, April 15, May 15, September 15, and October 15, 2022. The observed measurements were one month following the final foliar application.

1. Seedling height (cm) was measured using a standard metric measuring tape.
2. The stem diameter (mm) was assessed with a Vernier calliper.
3. The total number of branches per seedling was determined by counting all lateral branches emerging from the main stem.
4. Total leaf count (leaves seedling^{-1}) was similarly recorded.
5. Leaf area (cm^2) was quantified using an American-manufactured Leaf Area Meter, Model 20-CI, which operates via optical scanning.
6. Chlorophyll content (SPAD units) in the leaf was measured *in situ* using a SPAD chlorophyll meter.
7. Soluble carbohydrate concentration in the leaves (mg g^{-1} dry weight) was determined spectrophotometrically at 490 nm using UV–visible absorbance.

Experiment design and data analysis

The experimentaltreatments were distributed in a two-factorial experiment, organic fertilizer, date palm waste, and (X-Humate 85% extract applied using a completely randomized block design (CRBD) with three replications. The data were analyzed using GenStat 12thVSN international (Payne, 2009) software, where the ANOVA tables were performed, and the means were compared according to Duncan's multiple range tests at a probability level of 0.05 [21] (Hoshmand,2018).

Table 1: Physical and chemical properties of organic fertilizer (palm frond compost)

Component	pH	E.C	Mg	Fe	N	P	K	Ca
Value/percent	7.04	2.66 dsm^{-1}	0.85%	0.42%	2.30%	0.65%	2.80%	2.93 %

Table 2. Organic fertilizer extract X-Humate 85%

Component	N	K_2O	Fulvic acid	Humic acid	pH
Value/percent	0.6 – 3.6 %	10%	15%	65%	9-11

RESULT AND DISCUSSION

1. Plant Height (cm)

Data presented in Figure 1 indicate a statistically significant enhancement in seedling height due to organic fertilization with palm frond waste. The highest mean value of 145.5 cm was recorded for the 40 g seedling^{-1} treatment, exceeding that of the control, which exhibited the lowest value at 118.1 cm. Similarly, foliar application of the organic extract (X- Humate 85%) at 10 ml L^{-1} significantly increased plant height to 141.3 cm, relative to the untreated control, which reached 125.0 cm. Moreover, an interesting interaction effect of the two factors was also noted; the joint treatment of the seedling of palm frond waste of 40 g per 1 and 10ml L^{-1} of the organic extract produced the highest recorded plant height of 156.9 cm. The converse was true, with the lowest value of 114.7 cm being obtained in the absence of both amendments.

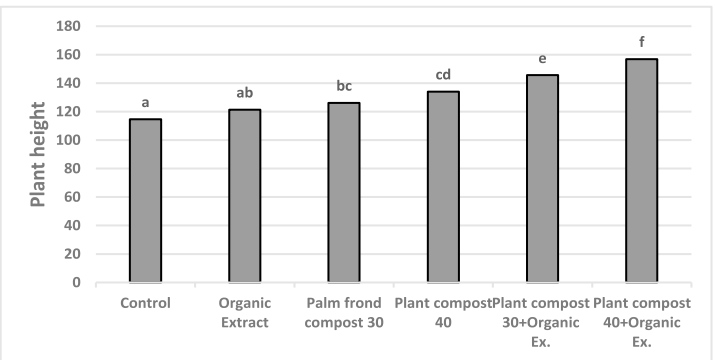

Figure 1. *Effect of palm frond compost in the presence of foliar organic extract (X -Humate 85%) on passion fruit sapling height. Bars that have different letter(s) are significantly different according to Duncan's multiple range tests (P≤0.05).*

2. Stem diameter (mm)

Data presented in Figure 2 indicate a significant difference in organic fertilization treatments for stem diameter. The 40 g/seedling^{-1} treatment resulted in a stem diameter of 2.26 mm, significantly different from the lower concentration and the control (1.28 mm). Spraying with the organic extract at a concentration of 10 ml/L significantly increased stem diameter to 2.11 mm, compared to the no-spray treatment (1.49 mm). The interaction between the two treatments showed significant results for this trait, with the combined treatment of palm frond waste (40 g/seedling^{-1}) and spraying with the organic extract at a concentration of 10 ml/L yielding the highest value of 2.71 mm, compared to the no-spray treatment (control), which resulted in the lowest value of 1.40 mm.

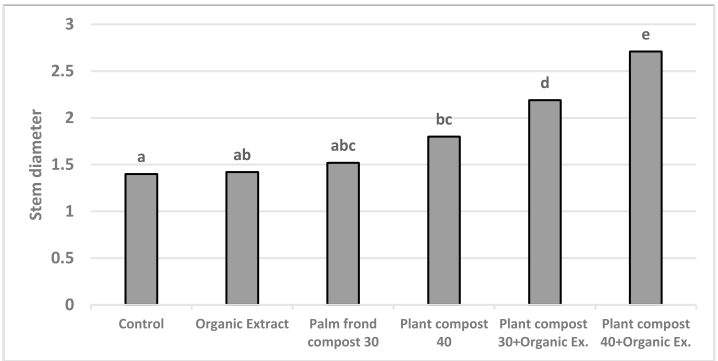

Figure 2. Effect of palm frond compost in the presence of foliar organic extract (X -Humate 85%) on the stem diameter of passion fruit sapling. Bars that have different letter(s) are significantly different according to Duncan's multiple range tests (P≤0.05).

3. Number of Branches (branch plant^{-1})

Data presented in Figure 3. The application of palm frond compost at 40 g sapling $^{-1}$ yielded the highest number of branches, with a mean of 6.20 branches plant $^{-1}$, whereas the control treatment resulted in only 2.38 branches plant^{-1}. Additionally, foliar application of X- Humate 85% at a concentration of 10 ml L^{-1} significantly enhanced branching, with an average of 5.41 branches plant $^{-1}$, compared to 3.46 branches plant $^{-1}$ recorded in the unsprayed control. A notable interaction effect between the two experimental factors was also observed; the combined treatment of palm frond waste at 40 g seedling^{-1} and organic extract spray at 10 ml L^{-1} achieved the maximum branching response, with 7.53 branches plant $^{-1}$. In contrast, seedlings subjected to neither soil amendment nor foliar spray exhibited the minimum value of 2.06 branches plant^{-1}.

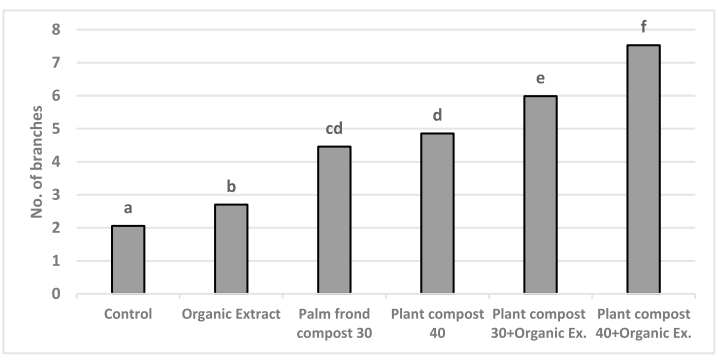

Figure 3. Effect of palm frond compost in the presence of foliar organic extract (X -Humate 85%) on the number of branches in passion fruit sapling. Bars that have different letter(s) are significantly different according to Duncan's multiple range tests (P≤0.05).

4. Number of Leaves (leaf plant^{-1})

Data presented in Figure 4. Likewise, to the former parameters, the organic fertilizer at 40 g sapling^{-1}increasednumber of leaves per plant to 74.97 leaves plant^{-1}, while the control treatment yielded 35.46 leaf plant $^{-1}$. Similarly, foliar application with X-Humate 85% at 10 ml L^{-1} significantly increased leaf number, producing an average of 65.93 leaves plant^{-1} compared to 47.87 leaves plant^{-1} in the unsprayed control. Moreover, the interaction between palm frond waste and organic extract spray was significant, with the combined treatment of 40 g seedling^{-1} and 10 ml L^{-1} resulting in the highest recorded value of 88.91 leaves plant $^{-1}$. In contrast, the untreated seedlings lacking both organic soil amendment and foliar application exhibited the lowest value of 29.64 leaves plant $^{-1}$.

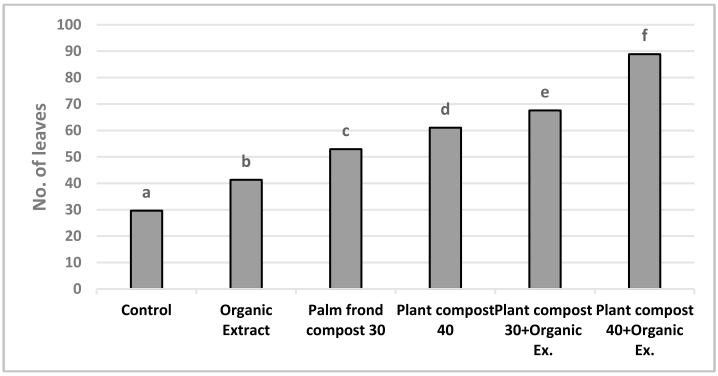

Figure 4. Effect of palm frond compost in the presence of foliar organic extract (X -Humate 85%) on the number of leaves in passion fruit sapling. Bars that have different letter(s) are significantly different according to Duncan's multiple range tests (P≤0.05).

5. Leaf Area (cm^2)

Data presented in Figure 5. In case of treatment effect on saplings leaf area, the highest mean value of 3.88 cm^2 was recorded due to application of 40 g seedling^{-1} palm frond compost, while the control group exhibited a much lower value at 1.82 cm^2. Similarly, foliar spraying with X- Humate 85% at a concentration of 10 ml L^{-1} significantly enhanced leaf area to 3.70 cm^2, in contrast to the unsprayed treatment, which produced a mean of 2.22 cm^2. A significant interaction effect between soil amendment and foliar application was also observed; the combined treatment of 40 g palm frond waste seedling^{-1} and organic extract spray at 10 ml L^{-1} resulted in the maximum leaf area of 4.90 cm^2. Conversely, the control treatment lacking both soil amendment and foliar spray displayed the lowest value of 1.31 cm^2.

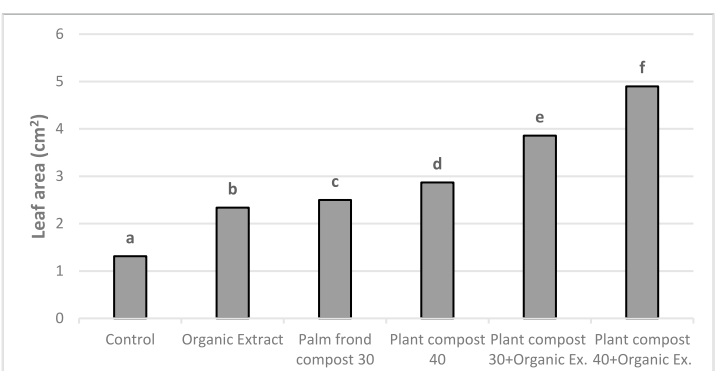

Figure 5. Effect of palm frond compost in the presence of foliar organic extract (X -Humate 85%) on leaf areain passion fruit sapling/ Bars that have different letter(s) are significantly different according to Duncan's multiple range tests (P≤0.05).

6. Leaf content of chlorophyll (SPAD units)

Data presented in Figure 6 showed significant differences were detected in leaf chlorophyll levels as influenced by organic fertilization with palm frond compost. The highest mean SPAD value of 53.2 was obtained from the 40 g seedling^{-1} treatment, whereas the control recorded 31.0 SPAD units. Likewise, foliar application of the organic extract (X– Humate 85%) at 10 ml L^{-1} significantly elevated chlorophyll content to 48.6 SPAD units, in contrast to the non-sprayed control, which yielded 37.0 SPAD units. The interaction of the two factors was the most effective, where the combined application of palm frond compost 40 g seedling^{-1} and 10 ml L^{-1}foliar X-Humate exhibited the highest chlorophyll content of 63.6 SPAD units. Conversely, the control treatment lacking both soil amendment and foliar spray displayed the lowest value of 30.0 SPAD units.

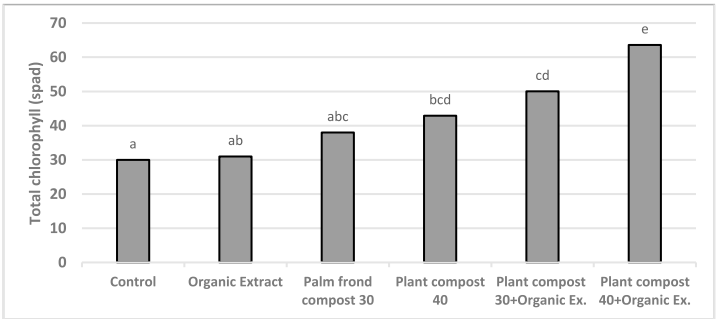

Figure 6. *Effect of palm frond compost in the presence of foliar organic extract (X -Humate 85%) on the leaf content of total chlorophyll in passion fruit sapling. Bars that have different letter(s) are significantly different according to Duncan's multiple range tests (P≤0.05).*

7. Leaf soluble carbohydrate (mg g^{-1} DW)

Data presented in Figure 7 showed statistically significant effects of organic fertilization and foliar X-Humate on total soluble carbohydrates in passion fruit leaves. The palm frond compost (40 g seedling^{-1}) resulted in carbohydrate content of 5.82 mg g $^{-1}$DW, compared to the control treatment 2.14 seedling^{-1}, respectively. In a similar manner, foliar X- Humate 85% at 10 ml L^{-1} elevated carbohydrates to 5.02 mg g^{-1}DW, surpassing the unsprayed control of 3.64 mg g $^{-1}$ DW. A pronounced two-factor interaction was observed, with the combined treatment of 40 g palm frond waste seedling $^{-1}$ and 10ml L^{-1} of organic extract yielding the maximum value of 6.40 mg g $^{-1}$ dry weight. Thus, the latter treatment recorded significant differences from all the other treatments, which resulted in values ranging from 1.13 to 5.52 mg g $^{-1}$ DW.

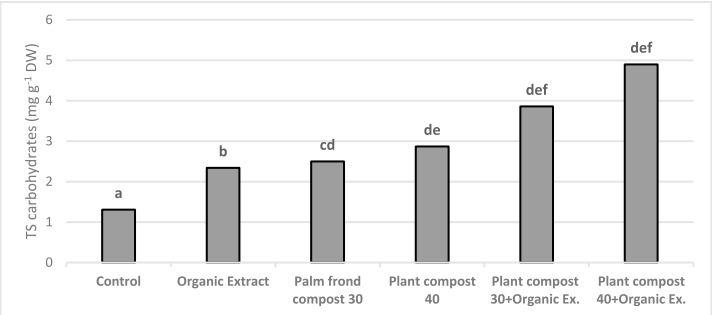

Figure 6. *Effect of palm frond compost in the presence of foliar organic extract (X -Humate 85%) on leaf content of total carbohydrates in passion fruit sapling. Bars that have different letter(s) are significantly different according to Duncan's multiple range tests (P≤0.05).*

The findings revealed the highest growth and improvement of all the evaluated vegetative traits, namely the plant height, stem diameter, branch number, leaf count, leaf area, and the leaf concentration of chlorophyll and carbohydrates after application of organic fertilizer, which was obtained from palm frond waste. These improvements are due to the fertilizer enhancing the infilled soil, increasing nutrient availability, and facilitating essential plant actions ([16]. These outcomes are consistent with previous findings.[22] identified the microbial enrichment effects of fermented organic fertilizers that are associated with improved nutrient mobilization and ultimately vegetative growth. [23] similarly highlighted humic acid enhancing vegetative parameters and encouraging mineral intake that agrees with the nutrient profile shown in Table 1 (N, P, K, Ca, Mg, and Fe).

[24] reinforced that increased mineral absorption shows up as higher height and higher stem widths of the plant. X-Humate is an 85% organic extract, which, in application along with foliar application, also induced and increased vegetative growth. The humic and fulvic acids obtained from Table 2 were sufficient for a rapid uptake through leaf tissues, which could promote the activation of enzymes related to the photosynthetic reaction and the translocation of photosynthates. This attempt is probably the reason for the increased branching and leaf growth. The increase in leaf quantity in the leaf, can be ascribed to the increases in nitrogen content and guanidine-based compounds present in the palm frond waste that help increase nitrogen availability and thereby promote leaf growth. Direct application of leaf surfaces through foliar spraying increased nutrient uptake and thereby improved physiological efficiency.

The additional leaf area and leaf chlorophyll when the extract is applied are attributed to the organic acid content of the extract, which promotes elongation of cells and tissue growth. This improved stomatal penetration, particularly with nitrogen and iron, allowed for the further accumulation of chlorophyll [25]. Furthermore, the addition of palm frond residues into the soil facilitated cation exchange and better nutrient availability, resulting in a better-performing root system that could be used to support photosynthesis and carbohydrate retention [26]. These findings are consistent with [27] results, which reported similar vegetative improvement in passion fruit seedlings after organic fertilizer was supplemented with soil amendment, while [28] measured enhanced growth traits, such as stem diameter, leaf number, chlorophyll content, and carbohydrate composition, following fertilizer with plant derivatives. According to the study results, application of organic fertilizer with palm frond waste and organic extract had a remarkable positive effect on all the traits of passion fruit seedlings. Such a change enhances their success in adapting to adapt in Iraq environment.

CONCLUSION

The results of this study have led to the identification of a range of specific attributes from the palm frond waste that can be used to support seedlings' development and enhance the characteristics of the fruits for sustainable development. Planting such fortified saplings in orchards will also facilitate developing them into future parent plants. In contrast to the previously mentioned, other perennial tropical fruit seedlings can be further studied for successful adaptation to Iraq's environmental conditions.

CONFLICT OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the staff of the [Department of Horticulture and Landscape, College of Agriculture, Al-Qasim Green University, Babil, Iraq] for their technical and general support.

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