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Research Article
Effect of Organic Substrates on Seedling Production of Giant Passion Fruit (*Passiflora quadrangularis* L.)

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Abstract
Background and Objective: *Passiflora quadrangularis* L., also known as giant granadilla, received attention from growers in recent years due to its aromatic flowers, unique and excellent fruit flavor. This research aimed to examine the effect of organic manures used for *P. quadrangularis* seedlings production. **Materials and Methods:** The experiment was designed in Randomized Complete Block Design (RCBD), with four treatments consisting of three different organic substrates (chicken, goat and rabbit) and control with six replications. The effect of the treatments was measured through weekly observation on the plant height, stem diameter number of leaves, chlorophyll index and growth rate. After the 4th month of seedling establishment, the root length, fresh weight and biomass of the aerial and root parts were determined and statically analyzed using Analysis of variance (ANOVA) with *post hoc* Tukey's test. **Results:** Among the treatments, the substrates with rabbit composite with soil and sand (T_2) exhibited significant Dickson's Quality Index (DQI), improving the original development of *P. quadrangularis* seedlings as the plant height of 167.25±1.65 cm, stem diameter of 7.79±0.16 mm and leaves accounted to 28.33±1.20. The fresh and dried aerial mass of 90.41±0.67 and 18.70±0.68 g, respectively and the fresh and dried root mass of 8.92±0.28 and 2.41±0.22 g, respectively was enhanced through the treatment. **Conclusion:** The constitution of organic substrate in rabbit provides better growth and making its use feasible in the production of *P. quadrangularis* seedlings.

Key words: DQI, organic manure, giant granadilla, passion fruit, production, seedling, survival

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Passion flowers are known to be one of the most fascinating plants of the tropics. They produce exotic flowers that are unique and extremely mesmerizing with juicy and aromatic pulp[1]. *Passiflora* is the largest genus in the Passifloraceae family consists of more than 500 species[2]. *Passiflora* species are mainly distributed in the Neotropics and only 23 species are native in Southeast Asia, Australia and Oceana[2]. The genus has approximately 50 species that bear edible fruits; however, only two species; *P. edulis* Sims (purple passion fruit) and *P. edulis* f. *flavicarpa* (yellow passion fruit) are widely cultivated for fresh fruit and juice production[3]. In addition, the lesser known *P. quadrangularis* L., known as giant granadilla, is also cultivated on a small scale for local consumption in certain countries[4].

Passion fruit is cultivated on a commercial scale at Peninsular Malaysia owing to the prevalence of suitable growing conditions and increase in demand[5] with the market price in Malaysia ranging from RM 15-16 kg^{-1}. The current passion fruit market has a tendency towards healthy and functional products. The popularity of passion fruits in the local market contributes assists cultivators and local farmers in gaining income, as seen from how the production of it becomes the primary income source in nearly all states in Brazil. This species is also a high-value export-orientated crop, with its seedlings, fruits and the second product being essential in nutraceutical and pharmaceutical industries[6-7]. The juice is very popular and accepted worldwide due to its fresh and unique aroma and flavour results of natural combination of volatile constituent in a well-balanced system including sugar and organic acids. The juice is also used for flavour in many food products, such as dessert, jam, jelly, ice-cream and yogurt[8-9]. Apart from the edible uses, the by-products of passion fruit plants have long been used in folk medicine and become increasingly important in modern medicine. *Passiflora* species are rich in phytochemicals, e.g., flavonoids, tannins, phenols, glycosides, fatty acids and alkaloids[10]. These essential elements are used anti-inflammatory[11], anticonvulsant, antimicrobial[12-13], anticancer[14] and anti-diabetic[15] treatments to treat osteoarthritis[16] and insomnia[7] and because of their high antioxidant effects[17].

Although *P. quadrangularis* could be propagated through seeds, cuttings and grafting, the predominant method of its production in Brazil is still the sexual or seminiferous production. Besides the sensitivity of the seedlings to abiotic elements, there is insufficient data regarding the seedling cultivations, propagation methods and adaptability. Therefore, more trials and data are necessary for effective large-scale production of *P. quadrangularis* seedling and improved cultivation in the nation. According to Costa *et al.*[18] and Cavalcante *et al.*[19], the use of suitable techniques for seedling formation, such as suitable substrates, planting materials, irrigation, nutrition and improvement of climate is important to promote healthy and vigorous plants production of *Passiflora* species.

Among all, substrates play an important role in the formation of good seedlings due to their importance in the promotion of the plants' growth and development especially the root system[20-22]. Alternatively, the combination of various substrates for the production of fruit types, such as compost from goat manure, poultry manure and cattle manure[19,23], rice straw[24] and empty fruit bunch[25]. Studies showed these materials generate improved substrate drainage and porosity, as well as increased water storage capacity, nutrient levels and microbial population assisting in the root development[26-28]. These properties could improve their production system performance in plants. It could be seen from the field observation on several farms for passion fruit that the primary issue of passion fruit seedlings cultivation was associated with direct implementation of various inexpensive alternative origins of organic waste for large-scale cultivation. Therefore, the present study aimed to evaluate the effect of different organic amendments on the early growth of *P. quadrangularis*.

MATERIALS AND METHODS

Sample collection and study area: This research was a collaboration project between Universiti Putra Malaysia Bintulu Campus, (UPMKB) (N03°12.45' and E113°4.68'), Sarawak, Malaysia and Gold Rabbit Farm, Bintangor (N 02°11.55' and E111.6°27.95'), Sarawak Malaysia. The farm focusing on the production of rabbits, chickens and goats' meats for local supply including the production of *Passiflora* species. The fresh organic manures were collected from this farm and brought back to UPMKB for further processing. Planting materials used in this study were seeds acquired from the commercial supplier Trade Winds Fruit, Windsor, California. The greenhouse pot experiment was conducted at UPMKB from December, 2018 to June, 2019 cultivation period.

Seed germination: The purchased *P. quadrangularis* seeds were subjected to four pre-germination treatments. The treatments were T_1: Seeds pre-soaked in water for 24 hrs, T_2: Seeds pre-soaked in water for 7 days, T_3: Seeds pre-soaked in water for 14 days and T_4: Seeds pre-soaked in water for 1 hr as control (as recommended by the supplier) in room temperature (27°C). The pre-germination treatments were planned to be completed at the same time to allow for the seeds to be sown at the same time. For each treatment 30 seeds were sown and randomly allocated by species. Watering was carried out manually when necessary. The effect of pre-germination treatment was studied periodically by counting the germinated seeds. Cumulative germination was recorded in every alternate day of sowing and continued until end of the germination. Germination percentage was calculated as number of seeds germinated per total sown seeds.

Organic amendment preparation and stabilization procedure: The organic amendments were prepared in the compost plot at UPMKB. Samples of fresh manures have been collected and tested to determine their initial chemical properties. The fresh organic manures (chicken, goat and rabbit) have been added with Empty Fruit Bunch (EFB) to with ratio 1:2 w/w and to get the ideal C:N ratio (15-30:1) prior to use as substrate. The composition was monitored regularly by recording their temperature fluctuation. After the temperature has fallen to a stable state which was less than 28°C the organic manures were collected and mixed up with soil and sand for preparing the treatments.

Treatment preparation and experimental design: The pot experiment was designed in Randomized Completely Block Design (RCBD) with four types of substrates and 6 replicates per treatment. The two weeks old (with 2 pairs of true leaves) seedling were transferred into the polybags. The substrate for passion fruit planting was prepared based on the following treatments. The treatments were T_1: Goat amendment+soil+ sand, T_2: Rabbit amendment+soil+sand, T_3: Chicken amendment+soil+sand and T_4: Control (soil+sand). The substrate was prepared in the polybags (8"×12") mixed with 2 volume of organic manure amendments with 1 volume of topsoil and 1 volume of sand.

Chemical characteristics of substrates combination: The organic amendments with topsoil and sand were characterized for its chemical properties as followed. The moisture content of the sample was determined by drying the sample until obtained constant weight. The pH of manures was determined in a ratio 1:2 (soil: distilled water suspension). The soil total C, N and organic matter were determined using Leco CHNS Analyzer. Availability P was extracted using double acid method followed by blue method[29].

Observation and data collection: Weekly observation has been made to record the plant height (cm) from the stem base until apical, stem diameter (mm) measured 5.0 cm from the base of the plant, number of leaves (n), chlorophyll index and growth rate have been recorded for 12 weeks. After the 12th weeks of observation the plants were harvested to record the data for root length (cm), fresh root mass (g), fresh aerial mass (g) and total fresh mass (g). Whereas the dry root mass (g), dry aerial mass (g) and total dry mass were obtained after drying in an oven at temperature 60°C until constant weight was obtained. The Dickson's Quality Index (DQI) has been calculated as followed:

$$\text{DQI} = \frac{\text{TDM}}{\left(\frac{\text{PH}}{\text{SD}}\right)+\left(\frac{\text{SDM}}{\text{RDM}}\right)}$$

where, DQI is the dickson's quality index, TDM is the total dry mass, PH is the plant height, SD is the stem diameter, SDM is the shoot dry mass and RDM is the root dry mass[19].

Statistical analysis: Analysis of variance (ANOVA) was used to detect significant differences among treatments whereas, *post hoc* Tukey's test ($p<0.05$) was used to compare treatments mean using Statistical Analysis System version 9.4.

RESULTS AND DISCUSSION

Seeds germination of *Passiflora quadrangularis*: *Passiflora quadrangularis* seeds exhibited slow and less germination. Pre-germination treatments carried out in the present study influence the germination period and germination percentage compared to the control. Germination for all treatments; T_1, T_2 and T_3 started earlier than the control (T_4). Basically, the longer the water treatment T_3: Pre-soaked in water for 14 days, the earlier the commencement of seed germination, although this was not significant with the treatment T_2: Pre-soaked in water for 7 days. The outer protective coat of the seeds soaked in water for 14 days was observed to open slightly during submerged in water. Seeds of *P. quadrangularis* treated with T_3 started to germinate after 4 Days After Sowing (DAS) and continued up to two weeks except in control which germination was started after 20 days (Fig. 1). Seeds of *P. quadrangularis* pre-soaked for 7 days also showed higher germination (86.67%) compared to control (53.33%). Pre-soaking the seeds in water at room temperature helps in softening seed coat and removal of inhibitors and reduces the

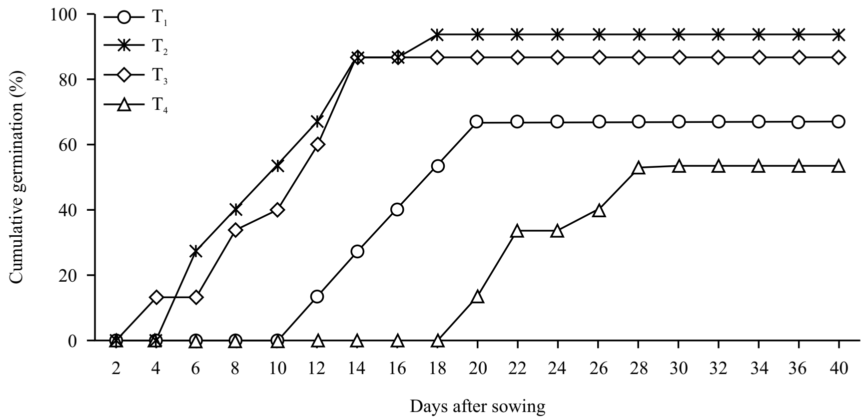

Fig. 1: Germination of *P. quadragularis* seeds in pre-germination treatments

T_1: Pre-soaked for 24 hrs in water, T_2: Pre-soaked for 7 days in water, T_3: Pre-soaked for 14 days in water and T_4: Control

Table 1: Chemical constitution of organic substrates

Materials	pH	Moisture (%)	Nitrogen (%)	Phosphorus (mg 100 g^{-1})	Carbon (%)	C:N ratio
Organic composites (manure+EFB) (temperature increase to 52°C and constant at 28°C)						
Goat composite	8.62±0.01^{b}	28.42±0.41^{a}	0.06±0.01^{a}	50.47±0.03^{a}	1.84±0.03^{a}	30:1
Rabbit composite	8.33±0.02^{c}	23.33±0.85^{b}	0.06±0.01^{a}	53.02±0.04^{a}	1.59±0.02^{b}	25:1
Chicken composite	9.29±0.02^{a}	16.85±0.29^{c}	0.06±0.02^{a}	3.46±0.06^{b}	1.26±0.03^{c}	21:1
Substrate (treatment) (organic composites+topsoil)						
Goat composite+soil+sand	7.88±0.05^{a}	21.63±0.28^{a}	0.04±0.01^{a}	87.16±0.02^{a}	1.65±0.02^{a}	
Rabbit composite+soil+sand	7.65±0.01^{a}	15.90±0.14^{b}	0.07±0.01^{a}	81.98±0.02^{b}	1.14±0.01^{b}	
Chicken composite+soil+sand	6.60±0.02^{b}	4.31±0.06^{d}	0.05±0.01^{a}	3.60±0.03^{c}	0.57±0.01^{d}	
Control (soil+sand)	5.29±0.31^{c}	7.29±0.03^{c}	0.06±0.01^{a}	1.53±0.04^{d}	0.65±0.01^{c}	

Significant difference was observed between the mean values in a similar column with various alphabets (a>b>c) in a similar classification at $p<0.05$ (ANOVA, Tukey's test). The values were included in means±standard error

time required for germination thus increases germination percentage (%). The results were supported by the study carried out in *Acacia catechu* where soaking in water gave better germination (80%) against control (62%)[30]. The authors also revealed the imbibitions of water by seeds help to break the dormancy by enlargement of the embryo resulting in an increase in fresh weight of seeds. Better germination (79-81%) was observed when seeds were soaked in water for 6 days against control in *Pterocarpus santalinus* seeds. Even though pre-soaked in water for 14 days speed up the germination process but seeds treated with water for 7 days (T_2) had a higher germination percentage than 14 days (T_3). The lack of germination in the seeds soaked more than a week may reduce the seeds viability attributed by imbibition, oxygen starvation and elevated temperature during submersion. This agrees with Mabundza *et al.*[31] who stated that a harmful effect of extended pre-soaking which restricted oxygen supply during some critical metabolic stage of germination.

C:N ratio of organic amendments and chemical constitution of substrates: The freshly collected organic manures were mixed with EFB for stabilization purposes. Direct application of organic waste into the field has many drawbacks as un-composed materials can cause immobilization of nitrogen and unavailable to plants[32]. Oil palm empty fruit bunch could be improving the recycling of nutrients, reduce the cost of fertilization, increase nutrient efficiency through a slower release and increase soil quality from a physical and biological point of view[33-34]. Mixing the empty fruit bunch for composting was a great choice because it can provide a better moisture, higher C:N ratio, content and good for bacterial activities during composting to degrade the organic matter. A balance in the carbon and nitrogen ratio is required since the microorganism will inert the carbon portion for energy and growth and the nitrogen for protein development. The value of C:N ratios for all the organic amendments are presented in Table 1 and were in the range of 20-30 that were within the optimum ratio for active microbial activity[35]. The C:N ratio for chicken, goat and rabbit composites were 21:1, 30:1 and 25:1 respectively. In general, microorganisms need about 25 times more carbon than nitrogen. C:N ratio of more than 35:1 slow down microbial activity as there is insufficient nitrogen for optimal growth[32]. Additionally, the moisture content also varied with manure and relatively higher content was recorded in goat amendments (28.42±0.41%), followed by the rabbit amendment (23.33±0.85%) and the least moisture was recorded in chicken amendments (16.85±0.29%). According to Anber *et al.*[36] uniform growth of passion fruit can be affected by the availability of water or moisture content as limiting factors that affecting the quality of the seedling to promote the development of the root system. Organic substrate provides good water retention for plant growth because they provide porosity and facilitates aeration[37].

Chemical compositions of substrate combinations (2 organic amendments:1 topsoil: 1 sand) are presented in Table 1. Among all the treatments, control (topsoil and sand only) showing lower pH with 5.29±0.31 and slightly higher pH was observed in goat 7.88±0.05 which was closed to neutral. According to Warren and Fonteno[38] several studies shown that the organic manure treatment can increase soil pH. Organic manure with livestock increases the pH but the effect is different on the content of organic matter, treatment amount and soil properties[39]. The nitrogen values fall within the range of 0.05-0.07% with no significant differences has been recorded between the substrate compositions and the control. Carbon content of chicken composite substrate (0.57±0.01%) was twice less than the goat (1.65±0.02%) and rabbit composite substrates (1.14±0.01%). Similarly, the phosphorus content significantly higher in goat and rabbit substrates; 87.16±0.02 and 81.98±0.02 mg 100 g^{-1}, respectively compared to the chicken substrate 3.60±0.03 mg 100 g^{-1}.

Effect of treatments on plant growth: The application of organic manure as a substrate substantially influenced the plant growth of *P. quadrangularis* seedlings. Data on plant growth and development was recorded on a weekly basis for 12 weeks. The plant height, stem diameter and number of leaves for *P. quadrangularis* seedlings are presented in Table 2. It was found that the plant height was significantly higher in T_2 (rabbit amendments+soil+sand) at 167.25±1.65 cm compared to other treatments. The T_1 (goat amendments+soil+sand) showed second higher plant height at 135.83±1.85 cm followed by T_3 (chicken amendments+soil +sand) at 94.90±1.98 cm. The least plant height was recorded in T_4 (control) at 26.30±2.42 cm. This finding could be illustrated by the substrate fertility and chemical states. The substrate contains chicken amendments and the control possessed lower chemical properties, which could aid in slower growth of the plant.

Table 2: Plant height, stem diameter, leaves and root size and chlorophyll content of *P. quadrangularis* seedlings under different substrate constituents

Treatments		Plant height (cm)	Stem width (mm)	Number of leaves (n)	Leaf length (cm)	Leaf width (cm)	Chlorophyll content	Root length (cm)	Root width (cm)
T_1	Goat composite+sand+soil	135.83±1.85^{bc}	7.66±0.11^{a}	26.00±1.00^{a}	14.59±0.69^{a}	11.21±0.66^{a}	43.78±1.52^{a}	25.66±0.95^{b}	7.37±0.38^{b}
T_2	Rabbit composite+sand+soil	167.25±1.65^{a}	7.79±0.16^{a}	28.33±1.20^{a}	15.91±0.56^{a}	11.12±0.26^{a}	42.74±0.88^{a}	32.00±0.72^{a}	11.23±0.93^{a}
T_3	Chicken composite+sand+soil	94.90±1.98^{c}	7.15±0.02^{a}	18.67±1.01^{b}	14.71±0.40^{a}	9.98±0.22^{b}	36.80±3.61^{a}	27.73±0.97^{b}	6.45±0.52^{b}
T_4	Soil+sand+soil (control)	26.30±2.42^{d}	5.92±0.10^{b}	10.67±0.88^{c}	9.24±0.88^{b}	5.64±0.63^{c}	23.41±2.43^{b}	25.67±0.88^{b}	4.50±0.29^{b}

Significant difference could be seen between the mean values in the similar column with various alphabets in the similar classification at p<0.05 (ANOVA, Tukey' test). The values present the mean±standard error

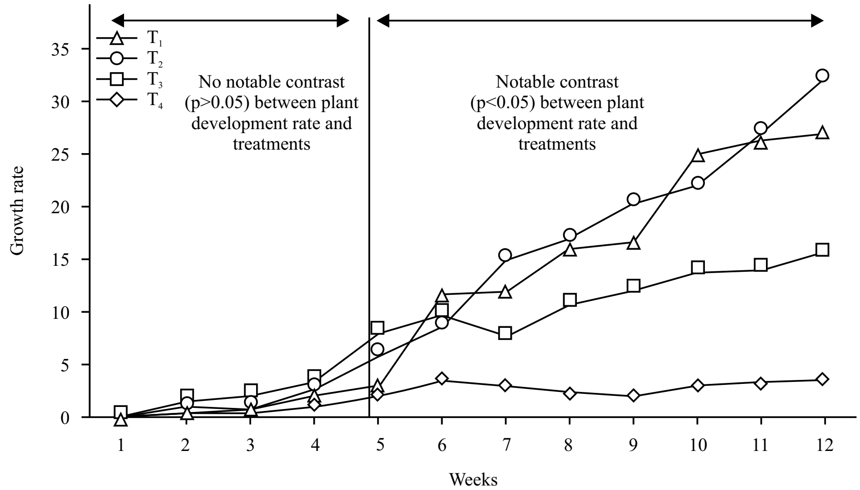

Fig. 2: Development rate of plant growth in various substrates

T_1: Goat composite+soil+sand, T_2: Rabbit composite+soil+sand, T_3: Chicken composite+soil+sand and T_4: Soil+sand treatments

Overall, there was no significant difference have been recorded in stem diameter among the treatments compared to the control. The stem diameter of chicken, rabbit and goat composites substrate ranged 7.15±0.02-7.79±0.16 mm compared to the control at 5.92±0.10 mm. Studies by Cavalcante *et al.*[19] reported that an increase in the diameter of the yellow passion fruit seedling stem was found as a result of the organic composite in the substrates. Lima *et al.*[40] highlighted that formulated substrates with cattle dung and vermiculite enhanced the stem diameter. Additionally, a higher number of leaves were recorded in T_2 at 28.33±1.20 and T_1 (26.00±1.00). Control showed the least number of leaves compared to other treatments.

Moreover, the leaves length and width in all the treatments with organic composites (T_1-T_3) were comparable with the leaves in T_4. While the leaves size in the treatments amounted to 14.59-15.91×9.98-11.21 cm, the measurement of the leaves in the controls amounted to 9.24×5.64 cm. This result was in line with Balyeri *et al.*[41], which highlighted that the organic manure impacted the development, yield and nutrients upon the treatment in the compost with the presence of nitrogen. Subsequently, the plant absorbed more nitrogen, which increased the number of leaves. Furthermore, rapid development was found after the 5th week of cultivation in treatment T_2 followed by T_1 and T_3, as shown in Fig. 2.

The chlorophyll content showed significant differences between the treatments. The chlorophyll contains indices that can be explained by the balance of available nutrients, aeration and the possible increment of humic substance to substrate of treatments. The plant chlorophyll is a factor that is directly related to the photosynthetic efficiency. The plants get the energy to grow and develop from the photosynthesis process[19]. The chlorophyll content was higher at 43.78±1.52 in treatment of T_1 (Rabbit amendments+soil+sand) and the twice lower chlorophyll content was recorded in T_7 (control) with 23.41±2.43. Silva *et al.*[21] stated that using different substrates found in treating organic manure afforded an increase in chlorophyll content in passion fruit leaves.

Successful establishment of seedling depends on their quality, which is capable of adverse field conditions, leading to a strong relationship of field establishment with root parameters[42]. The root system of a plant plays an essential role in plant growth and yield production[43]. Root length in the substrate with chicken composite significantly different from the other organic substrates and control. In terms of root width, the T_2 showed substantially higher root coverage at 11.23±0.93 cm, followed by in T_1 (7.37±0.38 cm) substrates consisted of goat manure. Organic fertilizer increases N and P availability in the substrate, thus increased the seedling height and root collar diameter that indicated organic fertilizer treatment affect carbohydrate distribution in the plant[44-45].

Impact of treatments on plant biomass and Dickson's Quality Index (DQI): The total fresh and dry mass of plant aerial and root parts are presented in Table 3. Aerial and root fresh and dry weight are good indicators for determining the quality of seedlings. Dry matter for a shoot is a good indication of rusticity, consequently good survival and initial performance in the field. The higher fresh weight of aerial parts and roots were recorded in T_2 (rabbit manure

Table 3: Fresh and dried mass of aerial and root parts of *P. quadrangularis* seedlings under different substrate constituents

Treatments		Arial fresh mass (g)	Root fresh mass (g)	Arial dry mass (g)	Root dry mass (g)	DQI (%)
T_1	Goat composite+sand+soil	78.68±0.71^a	8.14±0.56^a	14.44±0.68^b	2.40±0.08^a	0.73
T_2	Rabbit composite+sand+soil	90.41±0.67^a	8.92±0.28^a	18.70±0.68^a	2.41±0.22^a	0.82
T_3	Chicken composite+sand+soil	56.70±0.98^b	3.63±0.20^b	11.41±0.56^b	1.07±0.03^b	0.55
T_4	Soil+sand+soil (control)	16.41±0.78^c	2.36±0.26^{bc}	2.87±0.21^c	0.61±0.04^c	0.37

Significant difference could be seen from the mean values in the similar column with various alphabets in the similar classification at p<0.05 (ANOVA, Tukey' test). The values are presented as mean±standard error

amendments+soil+sand) with the values of 90.41±0.67 and 8.92±0.28 g, respectively. This is followed by the treatments T_1 which is goat amendments soil+sand. The lower fresh mass was recorded in control at 16.41±0.678 and 2.36±0.26 g in Ariel and root parts, respectively. Treatment with soil was inferior to other substrates in the fresh matter accumulation, which may be related to the conditions of fertility, even as high acidity, low base saturation and organic matter content, conditions that do not favour the development of seedlings with quality. According to Martinez *et al.*[46], organic fertilizer will produce higher total biomass than mineral fertilizer than enhance the new organ or shoot development.

Organic fertilizer application improves plant growth by supplying plant nutrients including micronutrients in slow release and improving the physical, chemical and biological properties of the soil, a better environment for root development by improving the soil structure[47]. For the dry mass also, a similar trend was recorded with higher biomass was observed in T_2. Barros *et al.*[48] found significance in the dry root mass when evaluating different substrates made with compounds of green manure and application of foliar biofertilizers in seedlings of yellow passion fruit. However, the substrate with manure provided dry mass increase and should be the best fertility conditions provided to the substrate. Organic amendments are frequently used to improve the soil structure, microbial diversity and plant nutrient status[49]. Besides, organic manure has low nutrient content, slow decomposition and different nutrient composition depends on organic material. Rabbit composition is suitable for purple passion fruit growth by supply adequate nutrients needed by the plant growth. Organic manure has multiple benefits due to the balance supply nutrients, including micronutrients, increased soil nutrient availability due to increased soil microbial activities, decomposition of the harmful elements, soil structure improvement to increase root development and increase soil water availability[45].

The Dickson's quality is a tool to evaluate seedling quality as a function of total dry matter, shoot height, stem base diameter, shoot dry matter and root dry matter index[50]. The ratio explained the overall plant potential for survival and growth in the field. Value in increasing order show increased potential for field planting establishment success. Dickson Quality Index is a promising indicator of seedling quality, integrating morphological traits and biomass distribution. The DQI values for passion fruit seedling based on treatments are presented in Table 3. The higher value of DQI in T_2 indicates organic amendments with rabbit substrate provided a better quality of *P. quadrangularis* seedlings and their potential for survival and growth in the field. This followed by goat manure (0.73) and less efficient is the control at 0.37.

CONCLUSION

The production of *P. quadrangularis* seedlings constitute one of the important stages of the cultivation system. This research enhancing the low-cost planting techniques to reduce the cost with the application of organic manure in make the seedling production feasible and to speed up growth of passion fruits. As a result, the rabbit composite+soil +sand (T_2) improved the early stages of the purple passion fruit seedling development. This result was in line with a more significant DQI value at 0.82. The constitution of organic amendments using rabbit manure provide better growth and making its use feasible in the production of purple passion fruit seedlings. Appropriate cultivation methods could be suggested for farmers or cultivators for high-quality commercial production of *P. quadrangularis* seedling.

SIGNIFICANCE STATEMENT

The rising popularity of passion fruit in the local and international markets is due to its nutraceutical and pharmaceutical application, which leads to earning opportunities for local farmers. This study discovered the low-cost planting techniques and the use of organic manure that leads to the economic viability of seedling production. This study will help the researchers to uncover the critical areas of low-cost seedling production techniques that many researchers were not able to explore. Based on this research a new theory has been obtained that rabbit composite can improve the production and feasibility of the giant passion fruit.

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