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EFFECT OF PLANTING MATERIALS AND ORGANIC AMENDMENTS ON THE PRODUCTION OF PURPLE PASSION FRUIT (*PASSIFLORA EDULIS* SIMS.) SEEDLINGS

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Abstract

The rising popularity of passion fruit (*Passiflora edulis* Sims) in the local and international markets is due to its nutraceutical and pharmaceutical application, which leads to economical opportunities for farmers in Malaysia and worldwide. The production of seedlings comprises crucial phases of the cultivation system through the selection of substrate and planting materials for the development of seedlings and plant conditions in the field. Accordingly, this research aims to the examine the effect of organic manures and planting materials used for purple passion fruit seedlings production. The pot experiment was design following the Randomized Complete Block Design (RCBD) with factorial arrangement 4 x 2 (4 types of substrates x 2 types of planting materials) with 6 replication per treatment. The Kaplan-Meier analysis recorded that softwood cutting had a higher seedling survival rate of 83% to 100% in comparison to semi-hardwood cutting, with a lower survival rate of 0% to 50%. Among the treatments, the substrates with rabbit composite and soil with softwood cutting (T1) exhibited more significant Dickson's Quality Index, improving the original development of purple passion fruit seedlings as the leaves amounted to 24.67±1.45, stem diameter of 6.32±0.55 mm, and plant height of 139.33±8.29 cm. The fresh and dried aerial mass of 48.58±0.74 g and 11.51±0.38 g, respectively, including the root mass of 10.23±0.37 g and 2.13±0.35 g was enhanced through the treatment. Notably, the composition of organic rabbit composite and softwood cutting improved the cultivation and feasibility of the passion fruit seedlings.

Key words: Cutting, Organic manure, Production, Purple passion fruit, Seedling.

Introduction

Generally known as passion fruit, the *Passiflora* plants are possibly the most outstanding species of the tropics due to their attractive appearance of the flower, its aroma, and the taste of the fruit. Passion fruit belongs to the family of Passifloraceae comprises of 18 genera including genus *Passiflora*. This genus consisting of more than 500 species somehow only two forms of *P. edulis*; i.e., *P. edulis* f. *edulis* (Purple passion fruit) and *P. edulis* f. *flavicarpa* (Yellow passion fruit), are notable for their commercial production for fresh fruit and juice market (Bernacci *et al.*, 2008).

The *Passiflora* plant is cultivated throughout South America and Central America (Vanderplank, 2000; Krosnick & Freudenstein, 2005), including Ecuador, Colombia, Peru, Australia, New Zealand, South Africa, and Hawaii. Furthermore, the tropical climate in Malaysia makes it suitable for the production of passion fruit plants. 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. Passion fruit is also a high-value export-orientated crop, with its fruits and the byproduct (e.g., leaves, rinds and seeds) being essential in nutraceutical and pharmaceutical industries (Costa *et al.*, 2011; Ramaiya *et al*., 2019).

Although passion fruit 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 passion fruit 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 passion fruit seedling and improved cultivation. Cavalcante *et al*., (2016; 2013) and Costa *et al.*, (2011) highlighted that the implementation of appropriate methods of seedling cultivation, including fertilizers, climate, irrigation, planting materials, and compatible substrates were essential for robust cultivation of passion fruit.

Substrates are the essential elements in the production of good seedlings as they assist in the development of a plant, particularly the root system (Akinboye *et al.*, 2016; Cruz *et al.*, 2008; Silva *et al.*, 2010). Alternatively, the combination of various substrates for the production of fruit types, such as the compost from cattle, poultry, and goat manures (Irshad *et al.*, 2013; Anyasi & Atagana, 2014; Cavalcante *et al.*, 2016), rice straw (Li-li *et al.*, 2018), and empty fruit bunch are can be used (Siddiquee *et al.*, 2017). It was found in earlier research that these materials led to enhanced substrate drainage and porosity, higher microbial population, nutrient levels, and larger water storage capacity, that enhanced root development (Barthod *et al.*, 2018). The selection of planting materials is also an important factor determining seedling quality and duration of flowering and fruiting. Overall, the aforementioned could improve the production system performance in plants.

It could be seen from the field observation on several farms of passion fruit in Sarawak that the primary issue of passion fruit seedlings cultivation was associated with direct implementation of various inexpensive alternative origins of organic waste and the appropriate planting material for large-scale cultivation. Therefore, the current research attempts to examine the effect of organic manures and planting materials on *P. edulis* Sims seedling production.

Materials and Methods

Sampling area and sample collection: This research was performed at Universiti Putra Malaysia Bintulu Campus, (UPMKB) (N 03° 12.45' and E 113° 4.68'), Sarawak, Malaysia with the collaboration of Gold Rabbit Farm, Bintangor (N 02° 11.55' and E 111.6° 27.95'), Sarawak Malaysia. The farm focuses on the production of rabbits, chickens, and goats' meats for local supply, including the production of two acres of purple passion fruit plants. The fresh organic manures were collected from Gold Rabbit Farm, Bintangor and were processed to UPMKB. The planting materials of softwood and semi-hardwood cuttings were also taken from this farm, with a wet tissue covering the edge of the cutting to retain the moisture before the plants were transplanted.

Organic composite preparation: This process was performed in the compost plot at UPMKB. The collection and testing of the fresh manure samples were made to identify the initial chemical properties of the samples. The oil palm empty fruit bunch (EFB), in the bunches form were collected from Sime Darby Plantation, Estate Derawan, Jalan Miri-Bintulu. The fresh EFB bunches were brought to the laboratory and chopped into small pieces and air-dried for a week. The dried pieces were ground until obtaining the dust form. The prepared dust form of EFB, was incorporated with three types of fresh organic manures respectively, i.e., chicken, goat, and rabbitto obtain the appropriate C:N ratio (15-30:1) before being applied as a planting substrate. The temperature and moisture of the manure samples were regularly recorded.

Stabilization procedure: All the fresh manure samples were combined with the dust form of EFB with 1:2 w/w ratio, followed by a regular examination on their composition by identifying the irregular changes in the temperature levels. After a balanced temperature level was reached, which was lower than 28°C (Li-li *et al.*, 2018), the organic manure samples were taken and combined with soil before being treated. After the organic manure was stabilised, C:N ratio was calculated to measure the suitability of amended organic manure as a substrate for planting.

Treatment process: The preparation of the substrate for passion fruit planting was made according to the treatments. The four separate substrates involved in this study included (a) chicken composite and soil, (b) goat composite and soil, (c) rabbit composite and soil, and (d) control (soil only). The planting medium was filled into polybag 8" x 12" (203 mm x 305 mm) combined with two-volume (1.2 kg) of organic manure composites and one volume (0.6 kg) of topsoil. This was followed by the preparation of planting materials through the selection of (a) softwoods and (b) semi-hardwood cuttings. Specifically, softwood defined as the position of stem from 10-15 cm from the shoot, while semi-hardwood was known as the placement of the stem after 15 cm from the shoot.

Design of experiment: The design of the test on the pot was based on the factors in the Randomised Complete Block Design (RCBD), including a 4 x 2 factorial arrangement (four types of substrates including the control x two forms of cuttings) and six replicates in each treatment. The treatments assessed in this study are as follows:

Treatments	Compositions
Treatment 1 (T1)	Rabbit composite + softwood
Treatment 2 (T2)	Rabbit composite + semi-hardwood
Treatment 3 (T3)	Chicken composite + softwood
Treatment 4 (T4)	Chicken composite + semi-hardwood
Treatment 5 (T5)	Goat composite + softwood
Treatment 6 (T6)	Goat composite + semi-hardwood
Treatment 7 (T7)	Control (soil only) + softwood
Treatment 8 (T8)	Control (soil only) + semi-hardwood

Chemical properties of substrates combination: The organic composites and topsoil were exhibited specific chemical properties. The moisture content of the substrates was determined by drying until constant weight was obtained following the method of Osborne & Voogt (1978). Furthermore, the pH of the manures was measured with the ratio of soil to distilled water suspension amounting to 1:2. Leco CHNS Analyzer was used to determine the total soil compositions of carbon, and nitrogen, while the concentration of available P was measured through the blue method using UV-VIS spectrophotometer at a wavelength of 882 nm (Tan, 2005).

Investigation and information gathering: The plant was watered once every day. Weekly observations were made to record the plant height (cm), stem diameter (mm) was recorded using Vernier calliper, number of leaves (n) and chlorophyll index which were collected for 12 weeks. The measurement of the plant height was taken within the distance from the plant base until the placement of the apical meristem, while the stem diameter was measured within 5.0 cm of distance from the plant base. Growth rate was also calculated based on the measurement of plant's height per day. Following the 12th week of monitoring, the plant sample was harvested to record the data of root length (cm), fresh root mass (g), fresh aerial mass (g), and total fresh mass (g). The plant sample was dried in an oven at 60°C until a fixed weight was achieved, followed by the calculation of total dry mass, dry aerial mass (g), and dry root mass (g). Quality of the seedling produced were determined using Dickson's Quality Index (DQI) as follows:

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

where, DQI = Dickson's Quality Index, RDM = Root dry mass, SDM = Shoot dry mass, SD = Stem diameter, PH = Plant height, TDM = Total dry mass (Cavalcante *et al.*, 2016).

Statistical analysis: The notable contrasts between studied treatments were identified through the analysis of variance (ANOVA). A Tukey's test ($p<0.05$) was performed for the comparison between the means of the treatments through Statistical Analysis System version 9.4. An in-depth investigation was conducted on the analysis outcomes through two-way ANOVA and factor analysis to identify the association between the two factors. Additionally, non-parametric analysis through Kaplan-Meier was applied to measure the survivability of purple passion fruit cutting, which was linked to the treatments.

Results and Discussion

The chemical constitution of organic composites and substrates: In the case of the organic manure composites, EFB was incorporated into the organic manure to reach stability. Notably, oil palm empty fruit bunch could be recycled into nutrients in a plant nutrient cycle for waste management, reduction of greenhouse gas release and improvement in recycling plant material (Hoe *et al.*, 2016). The combination of the empty fruit bunch to be composted was a beneficial process as it improved moisture content, increased the C:N ratio, and suitable for bacterial processes for the degradation of the organic matter. However, the direct placement of organic waste into the field resulted in various disadvantages. To illustrate, N could lose its mobilisation and might be absent to plants when the materials were not composed (Ahmad *et al.*, 2006).

Table 1 presents the chemical constitutions of organic composites and substrate constitutions. The chemical constitutions of all the organic manure composites were found to be contrasted from each other. Furthermore, all the stabilized organic manures with EFB were somewhat alkaline, with the pH from 8.33±0.02 in rabbit composite to 9.29±0.02 in chicken composite. While diverse moisture contents were found with manure, more significant moisture content was found in goat composite (28.42±0.41%), and chicken composite were recorded with the lowest moisture content (16.85±0.29%) due to high porosity (Ogunwande *et al.*, 2008). Anber, (2013) highlighted that the uniform development of passion fruit could be influenced by water or moisture as the elements affecting the seedling quality for the growth of the root system. According to Scotti *et al.*, (2015), organic composites exhibit porosity and enhances aeration, which contributes to positive water retention for plant growth.

Similar total nitrogen constitution was observed in all the manure, while more significant phosphorus content was found in goat manure (504.70±0.03 mg kg^{-1}). However, the phosphorus amount was lower in chicken manure (346.20±0.06 mg kg^{-1}) and this was caused by the lower moisture content which reduced the solubility of the nutrient in the planting substrates. The carbon dioxide concentration was enhanced by the organic matter decomposition in the soil, which resulted in the development of carbonic acids and the dissolution of native P minerals. Subsequently, the P mobility in soil was increased. The carbon content of all the tested manure ranged from 1.34% to 1.42%. After the organic manure was stabilised, C:N ratio was calculated to measure the suitability of amended organic manure as a substrate for planting. A balance in the carbon and nitrogen ratio was required as the microorganism would immobilise the carbon portion for growth and energy, including the nitrogen for protein development. Generally, microorganisms require approximately 25 times more carbon compared to nitrogen. The value of C:N ratios for all the organic composites ranged from 15 to 30, making it the optimum ratio for active microbial activity (Golouke, 1991). Meanwhile, a wide C:N ratio, which exceeds 35:1, slows down microbial activities due to insufficient nitrogen for optimal plant development (Ahmad *et al.*, 2006).

Table 1. Chemical constitution of organic substrates (treatments).

Materials	pH	Moisture (%)	Total nitrogen (%)	Availablephosphorus (mg kg^{-1})	Carbon (%)	C:N ratio
Organic composites (Manure + EFB) (Temperature increase to 52°C and constant at 28°C)						
Chicken composite	9.29±0.02^{a} (9.27-9.33)	16.85±0.29^{c} (16.35-17.37)	0.06±0.02^{a} (0.05-0.07)	346.20±0.06^{b} (334.10-356.60)	1.42±0.01^{a} (1.41–1.42)	21:1
Goat composite	8.62±0.01^{b} (8.59-8.64)	28.42±0.41^{a} (27.70-29.12)	0.06±0.01^{a} (0.06-0.07)	504.70±0.03^{a} (504.30-505.30)	1.34±0.01^{b} (1.34–1.35)	30:1
Rabbit composite	8.33±0.02^{c} (8.30-8.37)	23.33±0.85^{b} (21.95-24.89)	0.06±0.01^{a} (0.06-0.07)	530.20±0.04^{a} (529.40-530.80)	1.41±0.01^{a} (1.40–1.42)	25:1
Substrate (treatment) (organic composites + topsoil)						
Chicken composite+ soil	6.60±0.02^{b} (6.57-6.63)	14.31±0.06^{c} (14.21-14.43)	0.05±0.01^{a} (0.04-0.06)	360.20±0.03^{b} (354.40-366.60)	1.57±0.01^{b} (1.56-1.59)	
Goat composite + soil	7.88±0.05^{a} (7.78-7.96)	21.63±0.28^{a} (21.07-22.01)	0.06±0.01^{a} (0.06-0.07)	871.60±0.02^{a} (871.20-872.00)	1.84±0.03^{a} (1.79-1.88)	
Rabbit composite + soil	7.65±0.01^{a} (7.63-7.67)	15.90±0.14^{b} (15.67-16.14)	0.07±0.01^{a} (0.06-0.08)	819.80±0.02^{a} (819.30-820.10)	1.59±0.02^{b} (1.55–1.64)	
Control (soil)	5.29±0.31^{c} (4.85-5.89)	7.29±0.03^{d} (7.24-7.33)	0.06±0.01^{a} (0.06-0.07)	153.00±0.10 (148.00-160.00)	0.65±0.01^{c} (0.64-0.65)	

Notable 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, while the values in the bracket represent the range

Table 1 illustrates the chemical compositions of substrate combinations of organic composites and topsoil. Among the treatments, lower pH of 5.29±0.31 was recorded from the control, while the pH of the goat was moderately higher (7.88±0.05) and nearly natural. According to Warren & Fonteno (1993), some earlier research illustrated that the soil pH could be increased through organic manure treatment with livestock. However, a different impact was obtained from this treatment in terms of treatment amount, soil organic matter, and soil elements (Liu *et al.*, 2010). Moreover, higher moisture level was found in the substrate with goat constituents (21.63±0.28%) and the rabbit constituents (15.90±0.14%), while the lowest moisture content was found in the substrate with chicken composite (14.31±0.06%). The nitrogen percentage ranged from 0.05% to 0.07%, and no notable difference was found between manure constituents and control. There were no significant differences ($p<0.05$) recorded in total nitrogen constitution in all the manure. However, more significant phosphorus content was found in substrate amended with goat manure (871.60±0.02 mg kg^{-1}) and rabbit manure (819.80±0.02 mg kg^{-1}) compared to soil only (153.00±0.10 mg kg^{-1}). Similarly, the carbon concentration was also increased ranging from 1.57% to 1.84% in the substrates having organic amendments.

Survivability of purple passion fruit cuttings upon diverse treatments: Kaplan-Meier was a non-parametric analysis conducted on the survivability of passion fruit cutting, including the softwood and semi-hardwood present in diverse substrate compositions. Figure 1a (softwood cutting) and Figure 1b (semi-hardwood cutting) illustrated the curves of passion fruit seedling survivability with treatments. As a result, the figure above indicated the difference between the survivability of softwood cutting and semi-hardwood cutting. The 12-week records regarding the fruit cuttings indicated higher survivability for the softwood cutting in all the treatments in comparison to semi-softwood cuttings. In this case, the survival rate ranging from 83% to 100% was recorded from the softwood cutting, while the range of the survival rate of semi-hardwood was from 0% to 50% in all the substrates with organic manure composites, leaving 83% of control as an exception. Moreover, the higher survival rate of softwood cutting was possibly due to the dividing capability of the active cell, high-rate production of the new roots, and the cell ability to absorb the nutrient from the substrate and for continuous growth (Jung *et al.*, 2008). On the other hand, several months were required for the root production by the semi-hardwood. Overall, softwood was possibly more suitable as the planting materials for the cultivation of purple passion fruit seedling under diverse organic composites compared to the semi-hardwood.

The relation between two elements: The findings were investigated with more depth through two-way ANOVA by factorial analysis. Two factors were considered in this phase, namely 1) planting components and 2) substrate. It was indicated through the growth and survivability of *P. edulis* Sims that a notable relationship between the two factors was present at $p<0.01$. The interaction was observed from all the parameters, while no notable interaction was found from the root width (Table 2). Therefore, it is conceivable that the result of this study showed a strong interaction between these two factors and a similar trend was observed in the growth of *Bougainvillea spectabilis* plant (Eed *et al.*, 2015) in different growing media and stem cutting.

The impact of treatments on plant growth: The use of organic manure as a substrate had a significant effect on the growth of purple passion fruit. The weekly data collection on plant growth was performed for 12 weeks. Table 3 presents the stem diameter, plant height, and the number of leaves for passion fruit seedlings. It was found from the analysis that the plant was longer than T1 by a significant amount (rabbit composite + softwood cutting) at 139.33±8.29 cm in comparison to other treatments. A longer plant could also be seen from T2 (rabbit composite + semi-hardwood cutting) at 102.33±8.37 cm and T5 (goat composite + softwood cutting) at 84.33±9.49 cm. The shortest plant was observed T4 (chicken composite + semi-hardwood cutting) at 12.67±1.45 cm, with the control at 13.33±0.88 cm. This finding could be illustrated by the substrate fertility and chemical states. While the substrate exhibited chicken composite, the control had lower chemical elements, which could lower the plant growth rate. Overall, significant stem diameter was observed from all treatments compared to the control.

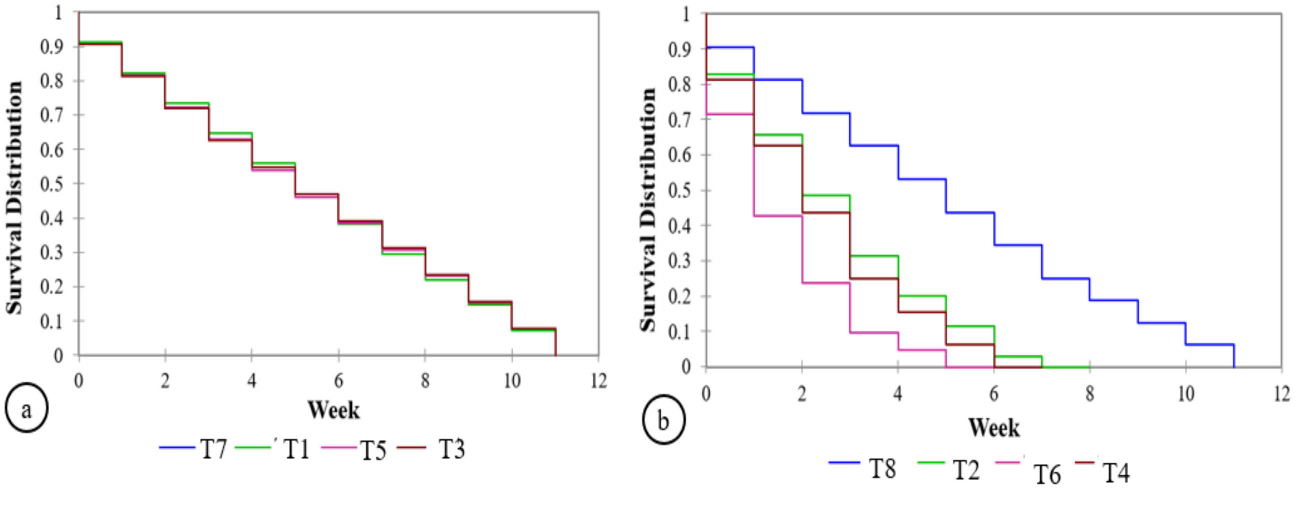

Fig. 1. Survival administration functions of (a) softwood cutting (b) semi-hardwood cutting in different planting compositions.

Table 2. Significance levels of diverse elements and interactions.

Source	Plant height	Stem diameter	No. of leaves	Leaves length	Leaves width	Leaves area	Root length	Root width	Fresh aerial mass	Fresh root mass	Dry aerial mass	Dry root mass
Planting material (P)	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**
Substrate (S)	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**
Interaction												
P X S	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p<0.01**	p=0.385^{ns}	p<0.01**	p<0.01**	p<0.01**	p<0.05*

Note: *-Notable difference was observed at p<0.05, **-Notable difference at p<0.01 and ^{ns}-insignificant

Table 3. Plant height, stem diameter, amount and size of leaves, leaf area, chlorophyll amount, and the size of root for passion fruit seedlings cultivated with various substrate constituents.

	Treatments	Plant height (cm)	Stem width (mm)	Number of leaves (n)	Leaf length (cm)	Leaf width (cm)	Leaf area (m^2)	Chlorophyll content	Root length (cm)	Root width (cm)
T1	Rabbit composite +	139.33±8.29^{a}	6.32±0.55^{a}	24.67±1.45^{a}	13.07±0.59^{a}	15.39±0.82^{a}	100.87±6.30^{a}	47.70±3.18^{a}	24.67±2.6^{a}	9.67±0.33^{a}
	softwood	(120-150)	(5.16-5.82)	(18-27)	(11.9-13.8)	(13.76-16.34)	(89.2-110.8)	(41.43-51.77)	(20.0-29.0)	(9.0-10.0)
T2	Rabbit composite +	102.33±8.37^{b}	5.39±0.38^{a}	19.67±1.20^{ab}	13.47±1.02^{a}	11.46±1.64^{ab}	89.87±4.17^{a}	29.35±2.04^{b}	18.00±2.89^{ab}	7.33±1.67^{a}
	semi-hardwood	(89-117)	(4.65-5.92)	(13-22)	(11.5–14.9)	(9.14–14.63)	(82.4-96.8)	(26.67-33.40)	(13.0-23.0)	(4.0-9.0)
T3	Chicken composite +	62.00±13.80^{c}	5.80±1.11^{a}	13.00±1.08^{bc}	11.13±0.50^{a}	13.14±0.57^{a}	83.47±9.11^{a}	27.48±2.19^{bc}	30.00±8.54^{a}	3.33±0.67^{bc}
	softwood	(41-88)	(4.1-7.99)	(10-19)	(10.4–12.1)	(12.02–13.90)	(72.8-101.6)	(23.90-31.47)	(20.0-47.0)	(2.0-4.0)
T4	Chicken composite +	12.67±1.45^{d}	5.14±0.03^{a}	3.04±0.22^{d}	6.13±0.87^{b}	4.39±0.18^{cd}	12.17 ± 1.44^{c}	27.98±2.17^{bc}	4.10±0.30^{c}	2.13±0.03^{b}
	semi-hardwood	(9.5-15)	(5.10-5.13)	(0-4)	(4.4–7.1)	(4.00–5.70)	(9.4-14.8)	(25.47-31.89)	(4.1-5.1)	(2.1-2.8)
T5	Goat composite +	84.33±9.49^{bc}	5.57±0.30^{a}	20.67±1.13^{a}	13.4±0.12^{a}	14.35±1.61^{a}	84.91±6.90^{a}	31.94±0.38^{b}	14.83±0.60^{ab}	3.83±0.17^{b}
	softwood	(17-103)	(4.83-6.13)	(12-24)	(13.2–13.6)	(11.36–16.90)	(71.2-93.1)	(31.53-32.70)	(14.0-16.0)	(3.5-4.0)
T6	Goat composite+ semi-	13.33±0.98^{d}	4.92±0.30^{b}	4.20±0.34^{d}	7.09±0.74^{b}	4.51±0.25^{cd}	18.45±2.11^{bc}	29.89±3.03^{b}	6.25±0.10^{b}	2.40±0.06^{b}
	hardwood	(10-18)	(3.90-5.01)	(0-5)	(6.1–9.4)	(4.10–6.77)	(14.6-22.8)	(25.06-34.11)	(5.4-6.2)	(1.8-2.9)
T7	Soil + softwood	18.00±2.31^{d}	4.39±0.30^{b}	6.67±0.67^{cd}	8.47±0.66^{b}	7.13±0.54^{bc}	27.47±1.87^{b}	18.88±0.28^{c}	27.67±2.19^{a}	3.00±0.42^{bc}
	(control)	(10-22)	(3.81-5.46)	(2-8)	(7.1–9.2)	(6.10–7.94)	(24.0-30.4)	(18.43-19.40)	(25.0-32.0)	(3.0-6.3)
T8	Soil + semi-hardwood	13.33±0.88^{d}	4.84±0.46^{b}	4.00±0.58^{d}	6.50±0.40^{b}	4.86±0.25^{cd}	13.73±2.74^{bc}	29.18±3.19^{b}	15.17±4.04^{ab}	1.5±0.5^{bc}
	(control)	(10-16)	(3.82-6.09)	(2-9)	(5.8–7.2)	(4.44–5.18)	(10.8-19.2)	(24.00-35.00)	(9.5-23.0)	(1.0-2.5)

Significant difference could be seen between the mean values in the similar column with various alphabets (a>b>c>d) in the similar classification at p<0.05 (ANOVA, Tukey' test). The values present the mean ± standard error, while the range is represented by the values in the bracket

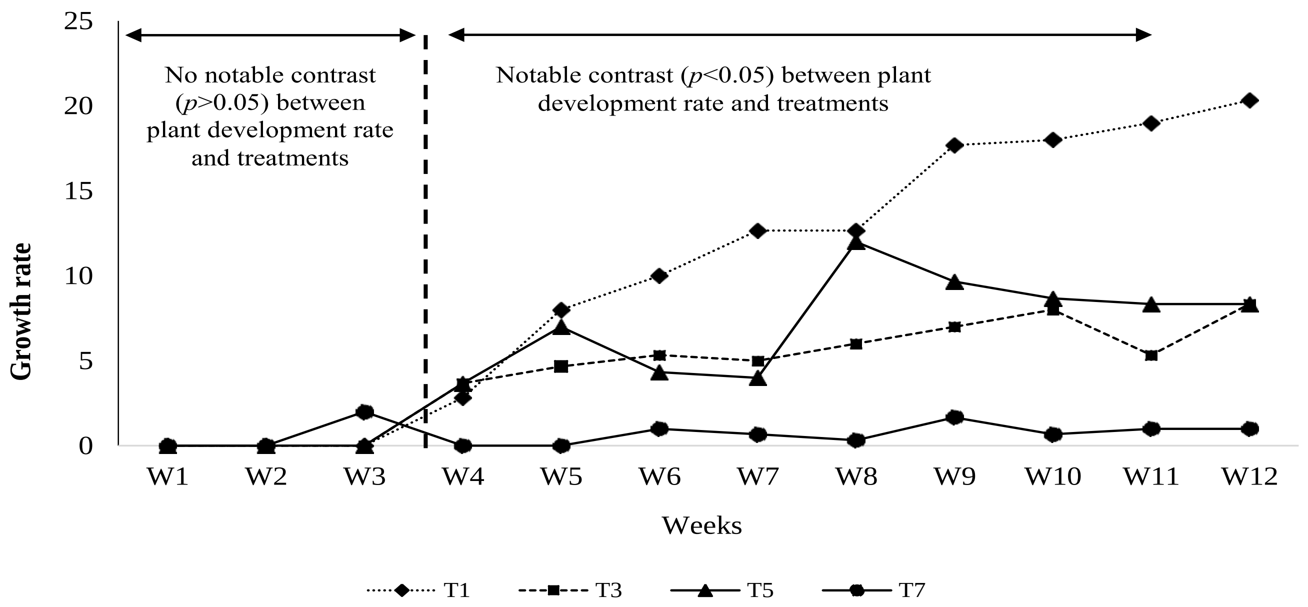

Fig. 2. Development rate of plant growth in softwood cutting in various substrates during T1 (rabbit composite + softwood), T3 (chicken composite + softwood), T5 (goat composite + softwood), and T7 (control) treatments.

Higher stem diameter was found from all the substrates in both softwood and semi-hardwood cutting, which ranged from 5.14±0.03 mm to 6.32±0.55 mm, while the shortest stem diameter was found in semi-hardwood and softwood treatments in control at 4.39±0.30 mm and 4.84±0.46 mm, respectively. An increase in the diameter of the yellow passion fruit seedling stem was found as a result of the organic composite in the substrates (Cavalcante *et al.*, 2016). Palacio *et al.*, (2011) highlighted that the use of diverse substrates generated with cattle dung, including soil and sand, enhanced the diameter of the stem. Moreover, T1 and T5 were found to have more leaves, including softwood with rabbit (24.67±1.45) and goat (20.67±1.13) composite, respectively, while the minimum number of leaves was found in control. Additionally, the semi-hardwood cutting in goat and chicken substrates exhibited the minimum number of new leaves within the 12-week duration.

Table 3 presents the plant development parameters of leaf sizes and area, chlorophyll amount, and root sizes. The length and width of the leaves in all the treatments with organic composites (T1-T6) were twice the measurements of the leaves in T7 and T8. While the measurement of the leaves in the treatments amounted to 11.13-13.47 x 11.46-15.39 cm, the measurement of the leaves in the controls amounted to 6.50-8.47 x 4.86-7.13 cm. Notably, a larger area was recorded for the leaves in the treatment with organic composites in comparison to the leaves in the control. This result was in line with Balyeri *et al.*, (2016), which highlighted that the organic manure had an impact on 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 4^{th} week of cultivation in treatment T1 (rabbit manure composite + softwood). The next treatments were T5 and T6 with goat composite, as shown in Figure 2. The root systems were gradually formed through the cutting during the first month of transplantation. Notably, the growth rate of the root was higher in softwood cutting in comparison to semi-hardwood cuttings.

Notable contrast could be seen between the treatments for the chlorophyll content. To illustrate, the chlorophyll consisted of indices presented by the balanced nutrition, aeration, and possible increase in the humic substance to the substrate of treatments. The plant chlorophyll was an element with direct relation to successful photosynthesis, in which the energy for the plant development was obtained from photosynthesis (Cavalcante *et al.*, 2013). More significant chlorophyll content (47.70±3.18) was observed for T1 treatment (rabbit composites + softwood cutting), while the chlorophyll in T7 (control + softwood) was lower at 18.88±0.28. Moreover, Silva *et al.*, (2010) highlighted that the use of various substrates in the treatment of organic manure enhanced the amount of chlorophyll in passion fruit leaves. It was demonstrated by Leghari *et al.*, (2016) that bigger leaf area was achieved with the organic manure when the nitrogen content was sufficient, which enhanced the vegetative development of the crop. To illustrate this finding, the leaf area was influenced not only by the nutrient combined with the organic matter, but it was also impacted by the enhancement in the microbiological content, and increase in population and diversity of soil fauna in the substrate (Sall *et al.*, 2015).

The seedling quality led to effective cultivation of seedling, which had the potential for an adverse field condition and a significant association between field development and root parameter (Chauhan & Sharma, 2017). The root system of a plant condition played a significant role in plant development (Li *et al.*, 2016). Furthermore, a notable difference was present between the semi-hardwood cutting and the control in terms of the root length of softwood cutting. In the case of root width, a larger root coverage was observed from T1 (9.67±0.33 cm) and T2 (7.33±1.67 cm) substrates with rabbit manure in comparison to other substrates. The increased presence of N and P in the substrate as a result of the organic fertiliser enhanced the diameter of root collar and seedling height, indicating that the use of organic fertiliser influenced the spread of carbohydrate within the plant (Han *et al.*, 2016).

The impact of treatments on plant biomass and Dickson's Quality Index (DQI): Table 4 presents the overall dry and fresh mass of plant aerial and root parts. It was stated by Costa *et al*., (2010) that high-standard cutting was possibly associated with the increase in the number of total dry matter and diameter cutting. Notably, the dry and fresh mass of the aerial and root weight was an effective determinant of cutting quality, with the dry matter for the shoot effectively indicating the rusticity, including positive survivability and initial performance in the field (Almeida *et al*., 2011).

The aerial parts and roots in T1 were recorded with more significant aerial and root fresh weight (rabbit manure composites + softwood cutting) at 48.58±0.74 g and 10.23±0.37 g, respectively. Meanwhile, the lower fresh mass was found for the semi-softwood with chicken (T4), goat (T6), and the control (T8). However, treatment with soil contributed to less significant results in other substrates, which were incorporated with fresh matter. This result was possibly associated with fertility although strong acidity, including a low amount of organic matter and base saturation, did not contribute to the cultivation of fertile seedlings. Martinez *et al*., (2016) highlighted that organic fertilizer would form larger total biomass compared to the mineral fertilizer and the improvement in a new organ or shoot formation. The use of organic fertiliser was emphasised by Ahmad *et al*., (2016) in their statement that plant growth could be boosted by enhancing plant nutrients, such as macronutrients, the chemical, biological, and physical characteristics of the soil, and the atmosphere for the plant growth. Furthermore, a similar pattern was recorded in the dry mass as more significant biomass was found in T1. In the evaluation of various substrates formed with combinations of green manure and the use of foliar biofertilisers in the yellow passion fruit seedlings by Barros *et al*., (2013), high dry root mass was recorded. The substrate with manure enhanced the dry mass, it should be the most suitable fertility environment for the substrate. High frequency of organic composite was used for the improvement in the soil form, microbial variation, and condition of plant nutrition (Tahat *et al*., 2020). Besides, organic manure exhibited a low amount of nutrition and slow decomposition, with the diverse nutrient constituents being based on the organic material. Rabbit composition was compatible with the development of purple passion fruit through the provision of sufficient nutrients for plant development. Notably, organic manure had a wide range of benefits due to balanced provision of nutrition, including micronutrients, enhanced availability of soil nutrition due to the increase in soil microbial activities, decomposition of negative components, and enhancement of soil form to facilitate root growth and improve the availability of soil water (Han *et al*., 2016).

The Dickson's quality an essential parameter usually used to assess the quality of cutting as the function of the shoot length, diameter of stem base, overall dry matter, shoot dry matter, and root dry matter index (Dickson *et al*., 1960). Furthermore, the probability of development and survivability in the field was illustrated by the ratio. The value in the increasing order indicated a higher possibility for a successful field planting. Notably, the Dickson's Quality Index (DQI) has potential as the determinant of the cutting quality, which integrates biomass distribution and morphological traits (Johnson & Cline, 1991). Based on Table 4, which presents the DQI values for passion fruit seedling according to the treatments, higher DQI was recorded at 0.50. This value implied that higher quality of organic composites for passion fruits cutting was obtained through rabbit and softwood, followed by goat manure. However, the less efficacious composite was found with the chicken manure although it was comparable. Additionally, Almeida *et al*., (2011) highlighted the importance of DQI when the substrate, which contained soil and cattle manure, was used to produce passion fruit. It was also stated by Almeida *et al*., (2011) that the result might be associated to water retention due to the combination of solidified earth and cattle manure, significant water retention in the material, and high porosity of the sand, which enhanced aeration. Overall, DQI is a positive determinant of quality cutting, which illustrates the possibility for plant development and survivability in the field (Chauhan *et al*., 2017; Johnson & Cline, 1991).

Table 4. Aerial dry mass, aerial fresh mass, root dry mass, and root fresh mass of passion fruit seedlings cultivated in various substrate constituents.

	Treatments	Arial fresh mass (g)	Root fresh mass (g)	Arial dry mass (g)	Root dry mass (g)	DQI (%)
T1	Rabbit composite + softwood	48.58±0.74^{a} (47.20–49.71)	10.23±0.37^{a} (9.62–10.89)	11.51±0.38^{a} (10.77–12.01)	2.13±0.35^{a} (1.77–2.83)	0.50
T2	Rabbit composite + semi-hardwood	30.58±2.35^{c} (26.00–33.78)	2.51±0.44^{bc} (2.04–3.38)	7.43±0.51^{b} (6.48–8.21)	0.91±0.09^{b} (0.81–1.09)	0.31
T3	Chicken composite + softwood	17.94±1.12^{d} (15.91–19.79)	1.15±0.02^{d} (1.12–1.18)	4.28±0.31^{c} (3.67–4.66)	0.60±0.10^{bc} (0.50–0.80)	0.27
T4	Chicken composite + semi-hardwood	2.04±0.25^{e} (1.72–2.53)	0.74±0.05^{d} (0.67–0.85)	0.73±0.09^{d} (0.59–0.89)	0.24±0.03^{c} (0.21–0.27)	0.18
T5	Goat composite + softwood	39.16±3.58^{b} (32.77–45.17)	3.42±0.27^{b} (2.93–3.88)	8.38±1.28^{b} (6.68–10.90)	0.80±0.007^{bc} (0.79–0.81)	0.36
T6	Goat composite + semi-hardwood	3.42±1.12^{e} (2.80–3.97)	0.97±0.09^{d} (0.77–1.12)	1.08±0.08^{d} (0.93–1.25)	0.27±0.06^{c} (0.18–0.30)	0.20
T7	Soil + softwood (control)	5.53±1.14^{e} (3.99–7.76)	1.35±0.15^{cd} (1.06–1.58)	1.53±0.29^{d} (1.15–2.11)	0.47±0.03^{bc} (0.42–0.52)	0.27
T8	Soil + semi-hardwood (control)	2.60±0.45^{e} (1.75–3.27)	0.78±0.04^{d} (0.70–0.84)	0.81±0.12^{d} (0.61–1.01)	0.32±0.02^{bc} (0.28–0.36)	0.21

Notable difference could be seen from the mean values in the similar column with various alphabets (a>b>c>d>e) in the similar classification at $p<0.05$ (ANOVA, Tukey' test). The values are presented as mean±standard error, while the range is presented through the values in the bracket

Conclusion

The use of organic manure, with the planting material being the essential element for successful seedling production and improved cultivation of passion fruits is important?. Following the measurement of survival rate in Kaplen-Meier analysis, the significant survival rate of 83% to 100% was observed from the softwood cutting in all the treatments in comparison to the semi-hardwood, which exhibited a survival rate of 0% to 50% in all the substrates with organic manure composite. As a result, the rabbit composite + soil using softwood cutting (T1) improved the early stages of the purple passion fruit seedling development. This result was in line with a more significant DQI value at 0.50. It could be concluded that the composition of organic composites with the use of rabbit manure and softwood cutting enhanced the cultivation of the purple passion fruit seedlings. Appropriate cultivation methods could be suggested to cultivators for high-quality commercial production of purple passion fruit seedling.

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