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Article

Effect of potting media and mulching on nursery and early field performance of passion fruit seedlings at Makurdi, Nigeria

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Abstract: Studies to evaluate the response of passion fruit seedlings in terms of emergence, nursery, and early field growth to growing media and mulching were carried out at the Teaching and Research Farm of Joseph Sarwuan Tarka University Makurdi between July and December 2018. Treatments consisted of five media, composted from readily available substrates. The five nursery media were; medium 1:1:2:3 (SB) composed of top soil + poultry manure + river sand; medium 2:1:2:3 (RHB) – rice hull + poultry manure + river sand; medium 3:2:3:1 (RHB) – rice hull + poultry manure + river sand; medium 4:1:4:3 (SDB) – sawdust + poultry manure + river sand and medium 5:1:2:3 (SDB) – sawdust + poultry manure + river sand. For the nursery experiment, treatments were the five potting media, while the field trial was a 5 × 2 factorial arrangement consisting of the five growing media and mulching status (mulch and no mulch). In both cases, treatments were laid out in randomized designs that were replicated three times. Results showed that there were no significant differences in all the emergence traits evaluated. However, medium M5 (sawdust based) showed superior performance in most of the seedling characters evaluated. Under field conditions, the sawdust based media (M4 and M5) gave the best growth of passion fruit seedlings compared to the other potting media. Application of mulch, however, did not elicit any significant response in plant growth. It is therefore conclusive that sawdust based growing media could be used to produce high quality passion fruit seedlings with the prospect of excellent performance under field conditions.

Keywords: potting media; emergence; mulching; seedling growth; passion fruit

1. Introduction

Passion fruit, which belongs to the Pasifloraceae [1,2], has about 500 species distributed in tropical and subtropical regions of the world [3]. It has two cultivated edible types: the yellow passion fruit (*Passiflora edulis* var. *flavicarpa*) and the purple passion fruit (*Passiflora edulis* var. *edulis*). The yellow passion fruit grows best under tropical conditions, while the purple passion fruit prefers subtropical/temperate climates [4,5]. The yellow passion fruit has higher fruit productivity and juice content, with a higher acid content compared to the purple one. It also tolerates most of the soil borne pests and diseases that affect the purple type, even though the latter has a better flavor [4]. The 30%–40% juice content of passion fruit when extracted can be consumed fresh or used as concentrate or as flavoring in certain foods [6]. Even its rind can be fed to cattle and pigs, its glycoside (passiflorine) is a sedative; and its fruit juice is valued as a digestive stimulant and treatment for gastric ulcers. Besides, the oil extracted from its seeds, which has similar properties to sunflower and soybean oil, is edible and of industrial importance [7].

Yellow passion fruit produces edible, canary yellow spherical fruits 6–12 months after planting [8,9] and they have a unique flavour. The comparatively high acid content of its juice is its most distinctive characteristic and is important in the processing and formulation of products containing fruit juice [10]. Yellow passion fruit fresh juice is considered a concentrate, due to its high acidity and strong aroma. It is mainly used in the preparation of diluted sweetened beverages [7]. The significance of the juice derives from its exotic flavor and nutritional value [11].

Yellow passion fruit has a more vigorous vine, higher yield potential, and produces larger fruit than the purple-fruited form [8]. Purple passion fruit is preferred for more pleasant flavors whereas yellow passion fruit is considered suitable for processing [9]. Within the Nigerian territory, yellow passion fruit is relatively unknown to farmers and hardly grown even though it is well suited to the ecology of Southern, Eastern and some parts of the Northern States of Nigeria [6,12]. At present, however, a growing number of farmers seem to be taking an interest in its cultivation.

Propagation of passion fruit in commercial fields is preferentially done by seeds [13], but the lack of uniformity of germination and seedling emergence that is reported by producers and nurseries, creates difficulties in raising quality seedlings and establishing productive orchards. Nursery seedling production in Nigeria is still largely undeveloped, in spite of its importance in horticultural crop production. Growing media influence the quality of seedlings produced there [14–16], their survival and growth in the field [17], and the eventual productivity of an orchard [18]. Few studies have been done on the raising of passion fruit seedlings for field establishment. For instance, Ndukwe et al. [19] evaluated different rates of poultry manure ranging from 0–40 t/ha for raising seedlings of two genotypes of passion fruit. Results indicated that the 20 t/ha rate gave the seedlings the seedlings the best growth performance. In another study, Ndukwe and Nwachikere [20] recommended sawdust (100%), and a combination of topsoil, poultry manure, and rice hull in volume proportions of 3:2:1 in the production of passion fruit seedlings in southeastern Nigeria.

Although, the yellow passion fruit has a promising future in Nigeria, the most pressing challenge at present is the inadequate agronomic package for highly successful cultivation [21]. Areas identified as requiring immediate attention includes mulching, fertilizer recommendations for optimum fruit yield and quality, among others [6]. In an attempt to reduce the negative effects of the harsh tropical environment, a form of cultivation that aims to reduce high temperatures and water losses by evapotranspiration using mulch is especially important. This is even more pertinent considering the shallow rooting nature of this crop as well as its continuous and vigorous growth. The decomposition of mulch cover sets in motion soil biochemical processes that result in enhanced soil physical and chemical properties and increased productivity [22].

Determining the effect of nursery media and mulching on the emergence and growth attributes of passion fruit appears worthwhile since nursery performance has been linked with vigorous seedling growth and productivity in the field. The inclusion of poultry manure as a component of the substrates for growing seedlings is meant to enhance the nutrient content of such growing media. This is because poultry manure is reported to possess the requisite nutritional content for enhanced plant growth [23].

Locally available substrates such as sawdust and rice hull, amended with poultry manure, have been successfully used in the raising of seedlings of other tropical perennials such as tamarind [24] and pawpaw [25]. In the present study, we hypothesized that poultry manure inclusion as a component of the potting mix would release its rich elemental nutrient content for plant nourishment, resulting in healthy and vigorous seedlings.

The aim of the present research was therefore to investigate the effect of potting media and mulching on the nursery and early field performance of passion fruit.

2. Materials and methods

The experiments were undertaken at the Teaching and Research Farm of Joseph Sarwuan Tarka University Makurdi, (Latitude 07°45′–07°50′ N, Longitude 08°45′–08°50′ E, elevation 98 m), Benue State located in Southern Guinea Savannah of Nigeria. The experiments were carried out between July and December 2018. Source of the seeds (conventional variety) was the Department of Crop Science, University of Nigeria, Nsukka.

2.1. Experiment 1

This experiment involved nursery production of seedlings using various growing media. The treatments comprised five (5) growing media composed as either soil- or soilless-based media. The media components were top soil (TS), sawdust (SD), Rice husk (RH), poultry manure (PM) and River sand (RS).

Details about growth media are summarized in **Table 1**.

Table 1. Media and combinations used for experimental essay.

Media	Combination
M 1	TS + PM + RS (1:2:3)
M 2	RH + PM + RS (1:2:3)
M 3	RH + PM + RS (2:3:1)
M 4	SD + PM + RS (1:4:3)
M 5	SD + PM +RS (1:2:3)

Abbreviation: TS = Topsoil; PM = Poultry Manure; RS = River sand; RH = Rice hull; SD = Sawdust.

Treatments were arranged in a completely randomized design (CRD) with three replications.

The different potting mixes were composted one month earlier, to ensure their proper curing. These media were potted in 7 L plastic containers. Each container had ten seeds planted and each treatment was made up of thirty seeds in three containers, replicated three times. In all, each treatment had 9 containers.

The media were carefully watered at a 3-days interval. Seedling emergence counts were made at 3-day intervals after the first seedling emergence was noticed. The emergence counts were used to derive the other emergence traits namely, emergence percentage (E%), emergence index (EI) and emergence rate index (ERI). The following formulae as adopted by Thokchom and Mandal [26] were used for the calculations:

$$E\% = \frac{Seedlings\ Emerged}{\text{Total number of seeds planted}} \times 100$$

$$EI = \frac{\sum(Number\ of\ seedlings\ that\ emerged)(DAP)}{\text{Total seedlings emerged}}$$

$$ERI = \frac{EI}{E\%\ \text{(in decimal)}}$$

where DAP = Days after planting.

At six weeks after planting, seedling growth parameters were taken to assess seedling performance in the nursery. Plant height was measured with a metre rule from the base of the stem to its tip. Leaf length was similarly measured with a metre rule from the base of the leaf to its apex. A metre rule was used to estimate leaf width at the broadest part of the leaf. Estimate of leaf numbers was done by counting. A sample size of three was used in estimating the growth parameters.

2.2. Experiment 2

Seedlings raised from Experiment 1 were utilized for transplanting in this experiment. The treatments consisted of five (5) different media composed of either soil or soilless-based media and two mulching levels. The media components and their combinations were as explained in **Table 1**. And the mulching treatments comprised of Mulched (M) and No Mulched (NM) plots. The experiment was a 5 × 2 factorial fitted into a Randomized Complete Block Design (RCBD) and replicated three times.

Seedlings raised from potting media were transplanted to the plots according to the experimental layout. Each plot's dimensions were 4 m × 3 m (12 m^2) and the plants were placed into 2 m × 1.5 m inter-row and intra-row spacing respectively to have four (4) plants per plot. Mulching was carried out by placing the mulching materials (dry spear grass and elephant grass) according to the treatment layout.

Data were collected concerning the vine length, leaf length and leaf width five (5) months after transplanting. The number of leaves and the number of branches were estimated two (2) and three (3) months respectively, after transplanting.

2.3. Data analysis

Data collected were subjected to Analysis of Variance (ANOVA) using the GENSTAT (2015) statistical software package. Significant means were separated using Fisher's Least Significant Difference (F-LSD) at 5% level of significance.

3. Results

3.1. Experiment 1

A summary of seedling emergence attributes is presented in **Table 2**. The emergence parameters under consideration did not respond significantly to the nursery media treatments. However, the M2 medium presented an emergence percentage of less than 50%. In terms of seedling growth the seedlings of M5 medium showed significantly higher values for leaf length (10.14 cm), leaf width (5.65 cm) and number of leaves (12.0), although the difference from the seedlings of M4 medium was insignificant (**Table 3**). The seedlings of M1 medium had statistically similar leaf length as M5 and M4 media seedlings. Vine length did not show any significant differences among the five growing media although M5 medium showed a strong tendency to perform better.

Table 2. Influence of nursery media on the emergence of passion fruit in Makurdi.

Treatments	Emergence percentage (%)	Emergence index (EI)	Emergence rate index (ERI)
M1	51.70	12.53	24.27
M2	43.30	9.77	23.00
M3	50.00	13.10	26.27
M4	50.00	12.37	24.54
M5	55.00	11.78	22.24
F-LSD ($P \leq 0.05$)	NS	NS	NS
P value	0.788	0.623	0.719

M1 = Soil-based media {SB – TS+PM+RS (1:2:3)}; M2 = Rice husk based media{RHB – RH+PRS+RS (1:2:3)}; M3 = Rice husk based media {RHB – RH+PM+RS (2:3:1)}; M4 = Sawdust based media {SDB – SD+PM+RS (1:4:3)}; M5 = Sawdust based media {SDB – SD+PM+RS (1:2:3)}; NS = Not significant; *P* value—probability value; F-LSD = Fisher's least significant difference.

Table 3. Effect of nursery media on the growth parameters of passion fruit in Makurdi.

Treatments	Leaf length (cm)	Leaf width (cm)	Number of leaves	Plant height (cm)
M1	8.03	4.89	10.60	18.40
M2	7.09	2.53	7.60	10.60
M3	4.37	2.49	8.00	16.70
M4	8.17	5.22	10.93	17.50
M5	10.14	5.65	12.00	19.00
F-LSD ($P \leq 0.05$)	3.44	0.86	1.16	NS
P vale	0.046	<0.001	<0.001	0.330

M1 = Soil-based media {SB – TS+PM+RS (1:2:3)}; M2 = Rice husk based media{RHB – RH+PM+RS (1:2:3)}; M3 = Rice husk based media {RHB – RH+PM+RS (2:3:1)}; M4 = Sawdust based media {SDB – SD+PM+RS (1:4:3)}; M5 = Sawdust based media {SDB – SD+PM+RS (1:2:3)}; NS = Not significant *P* value—probability value; F-LSD: Fisher's Least significant difference.

3.2. Experiment 2

Table 4 summarizes the main effect of growing media and mulching on vegetative growth of transplanted yellow passion fruit seedlings. The growing media influenced significantly all the growth parameters evaluated except for the leaf width. The M5 medium recorded the highest values in all the traits that showed significant response to the growing media namely, vine length (99.40 cm), leaf length (10.9 cm), number of branches (4.0) and number of leaves (14.1). This was followed by the M4 and then the M1 media. Quite unexpectedly, mulching of plots did not give them any advantage over those that were not mulched. Similarly, none of the interactions between growing media and mulching elicited any significant response in growth attributes.

Table 4. Main effect of nursery media and mulching on field growth of yellow passion fruit at Makurdi, Nigeria.

Treatment	Vine length (cm)	Leaf length (cm)	Leaf width (cm)	No of branches	No of leaves
Nursery media					
M1	70.00	9.65	5.37	3.00	16.00
M2	53.10	8.62	4.87	3.00	17.20
M3	37.40	6.03	3.50	2.17	8.30
M4	75.40	9.03	4.80	8.17	20.00
M5	99.40	10.9	6.22	8.67	31.70
F-LSD $_{(0.05)}$	40.26	3.98	NS	4.01	14.12
Mulching					
Mulch	66.40	8.55	4.87	4.67	18.90
No mulch	67.70	9.14	5.03	5.33	18.30
F-LSD $_{(0.05)}$	NS	NS	NS	NS	NS

M1: 1:2:3 (SB) – Top soil + Poultry manure + River sand; M2: 1:2:3 (RHB) – Rice hull + Poultry manure + River sand; M3: 2:3:1 (RHB) – Rice hull + Poultry manure + River sand; M4: 1:4:3 (SDB) – Saw dust + Poultry manure + River sand; M5: 1:2:3 (SDB) – Saw dust + Poultry manure + River sand; NS – Not significant; *P* value—probability value; F-LSD: Fisher's Least significant Difference.

4. Discussion

Variations in seedling performance of nursery media are normally ascribed to distinct physic-chemical properties of the composted media due to the relative proportions of their components [24,27]. The media utilized in this study had already been characterized in a previous study on the basis of their physical and chemical attributes [25]. The media exhibited wide variation in certain physical and chemical attributes, which probably informed their differing influence on seedling growth characteristics under nursery conditions. In this study, the sawdust based medium 1:2:3 (M5) exhibited superior performance concerning the leaf attributes and the plant height in the nursery.

Baiyeri [14] in the weaning of banana/plantain plantlets showed that the rice hull based media were better than the saw dust based ones. In contrast, Ugese [24] reported superior performance of saw dust based media in raising tamarind seedlings. Similar results have been found in the present study, where saw dust based media performed better than rice hull based media. It has been opined that different plant species could show preference for particular media based on the adaptive features of such species vis-à-vis the characteristics of such media. In an earlier study, Ugese et al. [28] found poorer performance of shea (*Vitellaria paradoxa*) seedlings in media with high water holding capacity, a feature that ordinarily, benefits plant growth.

The present study did not find any significant response of emergence attributes of yellow passion fruit to potting media in spite of the variations in the physico-chemical properties of these potting mixes. This contrasts with previous studies involving other species in which a significant response to nursery media was evident [23,24,27]. The emergence percentage of 43.3%–55.0% as observed in our study seems rather low. Other emergence traits (EI and ERI) appear discouraging. Seedling growth was improved by some of the media used in this study, such as M5, M4, and M1, in that order. However, media that will improve the emergence of the characters of passion fruit will most likely enhance seedling performance to a higher degree. Additional work could be done in this regard.

It is interesting that under field conditions, the sawdust based media, particularly medium 5, also increased seedling growth. The same media showed impressive growth under nursery conditions. This underscores the fact that potting mixes not only influence seedling performance in the nursery but also determine their growth performance thereafter, including orchard productivity [14,18]. In another study involving papaya, the saw dust based media not only enhanced survival of seedlings transplanted to the field but also facilitated more robust plant growth.

Mulching is expected to improve soil physical parameters and have favorable impact on plant growth [22]. It seems somewhat disappointing that, in our context, no advantage of mulching with respect to plant growth was observed. Ugese et al. [29] in a study involving the shea tree, observed no favorable effect of mulching on the growth performance of shea seedlings. This was thought to be due to the nature of the mulching material—spear grass—which pressed firmly on the soil surface, rather than aiding compaction of the soil surface. Materials used in the current study for mulching were also made up largely of spear grass and elephant grass. As such, they may have exerted a similar compacting effect on the soil, hence the results obtained. This, however, may not nullify the well acknowledged positive contribution of mulching to plant growth and development.

In conclusion, it is evident that sawdust based media compounded in the proportions used in this study could be utilized for raising high quality yellow passion fruit seedlings with the capacity for optimal growth under field conditions.

Author contributions: FDU conceptualized this work, designed the experiments and drafted the manuscript. AO and IA set up the experiments 1 and 2 respectively, collected and statistically analyzed the data. All authors have read and agreed to the published version of the manuscript.

Conflict of interest: The authors hereby state that there are no conflicts of interests related to this work whatsoever.

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