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(Research Article)

Some agronomic performances in the nursery of two varieties (yellow and purple) of passion fruit [*Passiflora edulis L.* (Passifloraceae)] grown on various substrates

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Abstract

Passiflora is one of the most like fruits. However, in Côte d'Ivoire, its cultivation is rare due to a lack of planting material. The soil generally used as a nursery substrate still doesn't give satisfactory results. This study aims to evaluate the influence of several substrates on germination and nursery growth of two passiflora varieties with a view to optimum production of planting material. Seeds of yellow and purple varieties were sown separately on five substrates: composted sawdust (S1), forest topsoil (S2), a mixture of forest topsoil and sawdust ash (S3), soil from UNA experimental plot (S4) and a combination of soil from UNA experimental plot and composted sawdust (S5) in polyethylene bags. The experimental set-up used was a split-plot with three replications. Main results showed that variety, substrate and variety-substrate interaction did not influence germination. Longest roots (16-18 cm) were induced on the forest topsoil (S2) and forest topsoil + ash (S3) substrates. While the highest number of roots was obtained with the two varieties grown on the S3 substrate (45.67 roots). The highest fresh weight was 3.1 g, corresponding to that of the purple variety harvested from the plot soil (S4). In conclusion, the best agronomic performances were induced by the S3 substrate with the purple variety.

Keywords: Passiflora; Germination; Root; Biomass

1. Introduction

Passion fruit, also known as grenadilla, is a climbing plant in the Passifloraceae family. It is native to South America, specifically the Amazonian lowlands of Brazil. It can be propagated by sowing seeds collected from ripe fruit or by cuttings, but also by grafting. Passiflora is cultivated for its edible fruit [1]. Passion fruit is more frequently consumed as a processed product (juice, cocktail, etc.). It is seen more as an additional fruit to exotic fruits. Passion fruit is more commonly used to flavour a fruit salad, in which it exudes all its fragrance, or to make more sophisticated desserts (sorbet, pastries, etc.) than in its natural state. In pharmacopoeia, boiled passion leaves are used to treat insomnia, overwork and malaria [2].

In Africa, passion fruit is produced in the East and South, mainly for the local market and for processing. For the most part, African producing countries have opted for fresh purple passionfruit, except South Africa, which has steadily developed production of hybrid fruit derived from crosses between yellow and purple passionfruit, intended for export [3].

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Passion fruit drinks are increasingly being produced locally and marketed. Its cultivation could be an excellent source of income for a significant proportion of the Ivorian population (farmers, juice producers at various levels, and even small-scale agri-businesses). These assets suggest good medium- and long-term prospects for all those involved in the production of fruit juices and by-products. In Côte d'Ivoire, apart from a few isolated plants found as hobby crops, there are unfortunately no large passiflora plantations. Passiflora cultivation is limited by premature flower and fruit drop, and by the lack of semen for planting. In Côte d'Ivoire, despite its importance, passiflora plantations are almost non-existent. It is cultivated by a minority of small producers [4]. This lack of passion fruit cultivation is essentially due to a lack of semen. The few semen on the market do not come from selection and are sold at very high prices (around 12,000 FCFA per 100 g). For the mass production of planting material for plants in general and passiflora in particular, topsoil is often used as a nursery substrate [5]. Unfortunately, optimal agronomic performance is far from being achieved with this substrate. It is therefore advisable to evaluate other substrates in order to obtain the best quality and quantity of plant material. The aim of this study is to evaluate the influence of substrate on germination and nursery growth of two passionflower varieties with a view to optimum production of planting material.

2. Materials and methods

2.1. Study site

The trials were carried out on a plot within Nangui Abrogoua University in Abidjan (Côte d'Ivoire). The average monthly temperature ranged from 25°C (August) to 29°C (December), while the maximum average rainfall was recorded in October (272 mm) and the minimum in February (29 mm) in the city of Abidjan. The vegetation of the UNA is that of the ombrophilous sector. It is the continuation of the Banco National Park. The ombrophilous sector is home to hydrophilous or ombrophilous forests that are rich in lianas and epiphytes [6].

2.2. Plant materials

Plant material consists of seeds from two varieties of passion fruit: purple and yellow (Figure 1).

Figure 1 Passion fruit seeds. (A) purple; (B) yellow

2.3. Methods

2.3.1. Basic constituents of substrates

Four basic constituents were used to formulate nursery substrates. These were forest topsoil, composted sawdust, soil from the experimental plot and sawdust ash.

2.3.2. Composition of nursery substrates

Five substrates have been formulated. Substrate S1 is made up entirely of composted sawdust, while substrate S2 is essentially made up of UNA forest topsoil. Substrate S3 is a mixture of forest topsoil and wood ash (v/v). Substrate S4 is composed solely of soil from the UNA experimental plot. Finally, substrate S5 is a mixture of composted sawdust and soil from the experimental plot (v/v).

2.3.3. Sowing seeds

The seeds were sown in 25.5 cm × 23 cm bags filled with substrates to a depth of 1 cm. The substrates in the nursery bags had been abundantly watered the day before and placed in the shade. In order to assess germination capacity and to have a sufficient number of seedlings to evaluate, two seeds were sown in each plastic bag. After emergence, the seedlings were separated to allow them to develop.

2.3.4. Experimental design

Split-plot system used consists of 3 blocks (Figures 2 and 3). Each block is made up of two sub-blocks: the varieties (main factor) and the substrates (5 substrates). Treatments from the second factor are randomly assigned to each sub-block (subsidiary factor). The blocks were spaced 50 cm apart, and the sub-blocks 25 cm apart. Within the same sub-block, batches of bags of one substrate (treatment) were separated by 20 cm. Twenty bags were used per treatment in each sub-block. That's 2 varieties X 5 substrates X 20 bags, so two hundred young plants were evaluated per block.

Figure 2 Experimental design

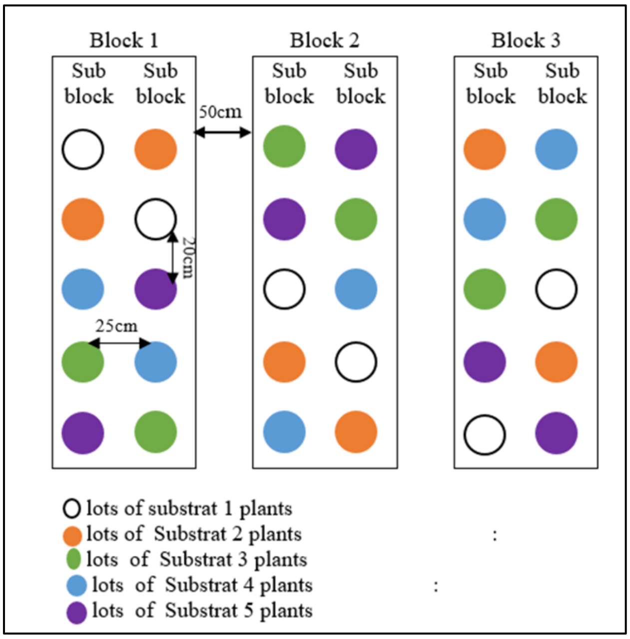


Figure 3 Schematic diagram of the experimental set-up

2.4. Statistical analysis of the data

STATISTICA version 7.1 software was used for statistical analysis of the data. One- or two-factor analysis of variance (ANOVA) was performed to assess the effect of different substrates on germination, rooting and biomass parameters. Where a difference was observed, Tukey's multiple rank test at the 5% threshold was performed to separate the means. For percentage and index, an arc-sine-square root transformation of the proportion was first performed before analysis of variance.

3. Results

3.1. Effect of variety and substrate on passiflora seed germination

In order to study the main effects of varieties and substrates and their interactions on germination parameters, a MANOVA was carried out. The results of this MANOVA are shown in Table 1. Analysis of these results shows that varieties, substrates and their interaction have no influence on passiflora seed germination ($P > 0.05$). The germination rate was 4.62% for the yellow variety and 3.19 % for the purple variety. Germination was spread over 8 days for the yellow variety and 9 days for the purple variety. Germination index was 3.69 for the yellow variety and 3.14 for the purple variety. T50 was 7.90 days for the yellow variety and 9.03 days for the purple variety.

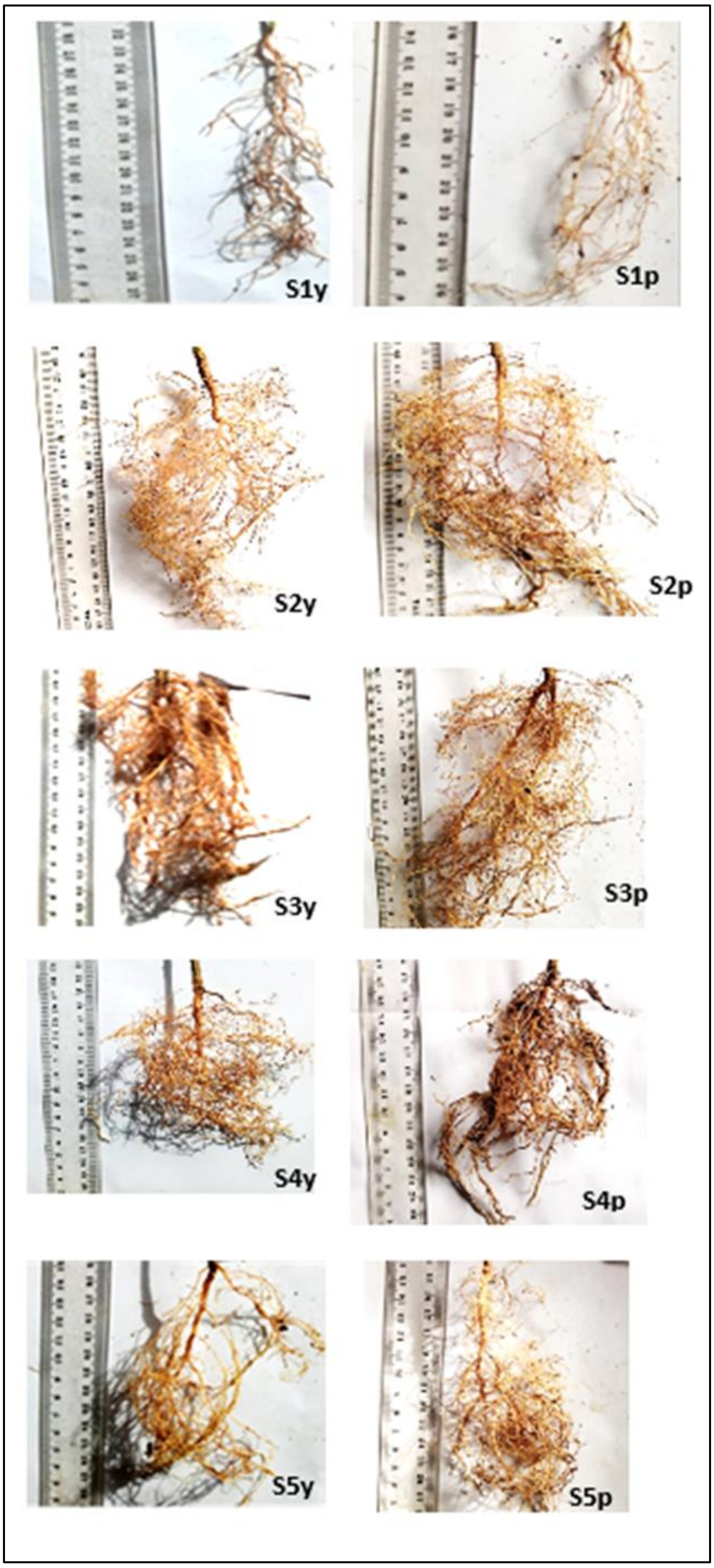
Table 1 Probability values of variables for germination parameters subjected to analysis of variance

Variables or factors	Germination parameters			
	TG	AGT	IG	T50%
Variety (P)	0.228	0.282	0.111	0.138
Substrates (P)	0.381	0.615	0.345	0.714
Interactions (P)	0.617	0.479	0.347	0.496

GR = germination rate; AGT = average germination time; IG = germination index; T50 = average time for 50% of seeds to germinate.

3.2. Effect of variety and substrate on passiflora rooting

After germination, the passiflora plants developed roots for growth (Figure 4). The results relating to this rooting are shown in Table 2. Analysis of these values shows that both the main effect of accession and the accession-substrate interaction had no effect on root length and number ($P > 0.05$). Substrate significantly influenced root length ($P = 0.005$) but had no effect on root number ($P = 6.01$). The longest roots (16 to 18 cm) were induced on the forest topsoil (S2) and forest topsoil + ash (S3) substrates. Root number was highest for the two varieties grown on substrate S3 (44.67 and 45.67 roots), while it was lowest for the Yellow variety on substrate S1.



Yellow variety on: composted sawdust (S1y); UNA forest topsoil (S2y); forest topsoil + wood ash (S3y); UNA experimental plot soil (S4y); composted sawdust + experimental plot soil (S5y) Purple variety on: composted sawdust (S1p); UNA forest topsoil (S2p); forest topsoil + wood ash (S3p); UNA experimental plot soil (S4p); composted sawdust + experimental plot soil (S5p)

Figure 4 100-day-old passiflora roots on different substrates

Table 2 Effect of substrates on rooting of two passiflora varieties

Variety	Substrates	*: root length (cm)*	*number of roots*
Yellow	S1	13.67 ± 1.15 ^{a}	17.67 ± 7.37 ^{cd}
	S2	17 ± 3.46 ^{a}	32.67 ± 4.16 ^{abcd}
	S3	16.33 ± 2.30 ^{a}	44.67 ± 6.50 ^{a}
	S4	12.67 ± 1.52 ^{a}	37.33 ± 4.16 ^{ab}
	S5	13.16 ± 2.75 ^{a}	24.67 ± 6.80 ^{bcd}
Purple	S1	12.5 ± 1.32 ^{a}	16 ± 1.73 ^{d}
	S2	18.67 ± 2.02 ^{a}	33.67 ± 7.02 ^{abc}
	S3	16.33 ± 3.05 ^{a}	45.67 ± 8.32 ^{a}
	S4	13.83 ± 1.75 ^{a}	36.67 ± 4.72 ^{ab}
	S5	13.67 ± 3.05 ^{a}	25.33 ± 4.16 ^{bcd}
P (Variety)		0.622	0.975
P (Substrates)		6.019	0.005
P (Variety *Substraties)		0.86	0.992

Within the same column, figures followed by the same letter are not significantly different at the,a = 5% threshold (Tukey test; standard deviation). S1: composted sawdust; S2: UNA forest topsoil; S3: forestopsoil+ wood ash; S4: UNA experimental plot soil; S5: composted sawdust + experimental plot soil.

3.3. Effect of variety and substrate on passion fruit plant biomass

After 100 days in the nursery, the fresh matter and then the dry matter of the yellow and purple varieties were weighed. The values collected were recorded in Table 3. Analysis of these values shows that fresh weight was significantly influenced by accession and substrate effects, but not by variety-substrate interaction. On the other hand, variety, substrate and variety-substrate interaction had no significant effect on plant dry weight. The highest fresh weight was 3.1 g, corresponding to the purple variety harvested from the plot soil (S4). The lowest fresh biomass came from the yellow variety grown on substrate 1 (0.2 g).

Table 3 Effect of substrate on plant biomass of purple and yellow passiflora varieties

Variety	Substraties	Fresh weight (g)	Dry weight (g)
Yellow	S1	0.2 ± 0.16 ^{c}	0.02 ± 0.01 ^{d}
	S2	1.06 ± 0.28 ^{bc}	0.57 ± 0.08 ^{ab}
	S3	1.63 ± 0.49 ^{abc}	0.73 ± 0.09 ^{a}
	S4	1.10 ± 0.41 ^{bc}	0.58 ± 0.16 ^{ab}
	S5	0.58 ± 0.48 ^{bc}	0.19 ± 0.09 ^{bcd}
Purple	S1	0.78 ± 0.53 ^{bc}	0.08 ± 0.02 ^{cd}
	S2	2.22 ± 0.96 ^{abc}	0.70 ± 0.18 ^{a}
	S3	1.9 ± 1.02 ^{ab}	0.54 ± 0.33 ^{abc}
	S4	3.1 ± 0.83 ^{a}	0.89 ± 0.23 ^{a}
	S5	0.71 ± 0,50 ^{bc}	0.21 ± 0.11 ^{bcd}
P(Variety)		< 0.001	0.292
p(Substraties)		< 0.001	6.593
p(Variety *Substraties)		0.106	0.157

Within the same column, figures followed by the same letter are not significantly different at the a = 5% threshold (Tukey test; mean ± standard deviation). S1: composted sawdust; S2: UNA forest topsoil; S3: forest topsoil + wood ash; S4: UNA experimental plot soil; S5: composted sawdust + experimental plot soil.

4. Discussion

The study of passiflora seed germination showed that variety, substrate and accession-substrate interaction did not influence passiflora seed germination. In other words, passiflora seed germination is neither variety nor substrate dependent. In fact, germination depends on the physiological state of the seeds and the hydration of the embryo. Germination begins with imbibition of the seed tissue, characterized by absorption of water from the external environment. This absorption of water promotes the synthesis of gibberellic acid, which in turn induces the synthesis of α'-amylase. The α'-amylase synthesized, promotes hydrolysis and degradation of reserve tissues containing carbohydrates, lipids and proteins into simple, assimilable forms (pyruvic acid, amino acids, fatty acids). As a result of this degradation, the seed swells and the tegument ruptures, usually at the micropyle, allowing growth points to emerge [7]. Germination also depends on respiratory intensity and enzymatic activity, which increase with seed water content. This process promotes the reactions required for germination, mitosis and cell elongation [8]. Water causes cells to swell and divide [9]. These results are in line with those of Nanti et al. (2020) [10]. These authors showed that in vitro cashew germination depended only on the physiological state and hydration of the embryo. The germination percentage was identical for all varieties. These results contradict those obtained by Castillo et al. (2020) [11]. These researchers showed that the germination rate of passion fruit was a function of variety. Germination time was between 4 and 7 days. Germination was therefore early in this study, compared with the germination time of six passiflora varieties observed by Marostega et al. (2017) [12]**.** This precocity could be due to the imbibition of seed tissues, characterized by an absorption of water from the external environment. The seeds were soaked in tap water for 24 hours, then dried at room temperature for 24 hours before being grown. During these treatments, the seeds would have begun to germinate. These results are not in line with those obtained by Castillo et al. (2020) [11], who observed delayed germination (one to three months) of pre-hydrated seeds of several types of passion fruit. The present study also showed that rooting was strongly influenced by substrate. The S3 substrate strongly stimulated root formation, unlike the other substrates. This could be explained by the fact that the mixture of topsoil and ash is suitable for the nursery of both varieties of passiflora plants. Indeed, ash can provide the plant with mineral elements that can be used immediately for root development. In addition, the forest topsoil, rich in organic matter and humus [5], would retain water and make it available to the plant's roots.

5. Conclusion

This study was carried out to evaluate the germination and growth of passiflora (passion fruit) on different substrates in the nursery. Germination results showed that neither variety, substrate type nor accession-substrate interaction had any influence on germination. The main effect of accession and the accession-substrate interaction had no effect on root length or number. Substrate significantly influenced root length, but had no effect on root number. Thus, the forest topsoil + ash substrate (S3) and the forest topsoil substrate (S2) favored the highest root growth and S3 induced the highest root number.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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