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Analysis of the Effect of Substrate on the Growth of Avocado Seedlings *(Persea americana* Mill*)*

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Abstract
The objective of the experiment is to study the germination and growth of young seedlings of the exotic fruit species (*Persea americana* Mill). It was conducted at the level of the botanical garden and educational greenhouse of the Agronomy department at the University of 20th August, 1955 - Skikda (Algeria).

The principle of the experiment was to compare the effect of 4 growing substrates on seed germination, and the growth of young plants of the species studied by testing five parameters that are: germination time, germination rate, the number of new branches, the number of leaves and the height of the stems.

The obtained results revealed that the best values of germination and growth parameters were those recorded for treatments carried out under educational greenhouse.

According to the obtained results, the best substrates for the cultivation and propagation of *Persea Americana* Mill are 80% earth + 20% peat, 55% earth + 25% sand + 20% peat, and 80% earth + 20% peat. In addition, Sand-only substrates (100% Sand), give favorable results for the speed of growth and the development of avocado seedlings after germination. For the germination of grains, the results are better in terms of germination quality unlike the results relating to quantitative aspects.

Keywords
Germination, Growth, *Persea americana*, Greenhouse, Substrate, Skikda

1. Introduction
Avocado (*Persea americana* Mill) or American pear, is an exotic fruit species native to Mesoamerica, commonly cultivated for its fruits; it belongs to the genus Persea of the Lauraceae family. This species was introduced in temperate zones in the 18 century; the first mention of its acclimatization in the southwestern United States dated to 1856. Its methodical spread in the same region, whose climate has many similarities with that of North Africa, began in 1871 with an experimental and study phase (Gaillarda, 1994).

The introduction of *Persea Americana* Mill in Algeria was in 1843 at Algiers Test Garden, with seeds received from the Antilles, where cultivation of this species is concentrated in the coastal regions (Bejaia, Boumerdes, Tipaza and Tizi Ouzo).

Avocado is a valuable food in the tropics especially for the rural class. The fruit has a high percentage of oil, which gives it great nutritional value; it even seems to develop more calories than meat (Pierre et *al*., 1931).

The agricultural development plan in Algeria is oriented towards the development of this type of species, which represents a sector that put on the future, and is an integral part of the economic and social life of the country. The latter, has different bioclimatic floors, which reduces the import bill and allows the creation of revenues and jobs by improving food safety standards.

However, the cultivation's development of these species requires the mastery of the techniques of their multiplication. The preparation of avocado seedlings by grafting is difficult and takes time (more than 2 years) as well as obtaining seedlings (hamidi et al., 2017).

In this context, this study was carried out to determine the favorable conditions for a greater cultivation and propagation of avocado (*Persea Americana* Mill), by testing the effect of different growing substrates on a number of parameters related to seed germination and the growth of young seedlings obtained for production and propagation by grafting.

2. Materials and Methods

2.1 Equipment

2.1.1 Plant Material

Germination tests were conducted on avocado seeds (*Persea Americana* Mill*)* collected locally. The seeds were collected from the exotic garden, which is part of the botanical garden of the University of 20 August 1955, Skikda (Algeria). This garden is composed of 24 species grouped into 18 families and divided into 20 botanical genera (Chalabi, 2017).

2.1.2 Substrates

Three basic elements were used for the preparation of the mixtures to be used as growing substrates, which are ordinary earth, sand and peat. The three elements were mixed with different proportions giving birth to different substrates.

2.1.3 Test Equipment

- Planting bags;
- Plastic lid;
- Trowel;
- Transplanter to fill planting bags;
- Manual watering can;
- Pelle.

2.2 Working Method

2.2.1 Period and Duration of the Experiment

The experiment was conducted during the period from mid-February to the end of June 2023. That is a study period of more than four months (137 Days).

2.2.2 Sites of the Experiment

Our study took place in the botanical garden and under the educational greenhouse of the agronomy department at the University of 20thAugust, 1955 – Skikda. Two experimental devices were demonstrated in both sites to compare the effect of climate and biotope conditions on germination and growth (Natural garden climate and greenhouse microclimate).

2.2.3 Conditions for Experimentation

The experiment was carried out over several successive stages logically staggered from the preparation of the plant material subject to this study to the planting of seeds in the planting bags.

2.2.3.1 Preparation of Avocado Seeds

The seeds are depulped of their avocado fruits then stored in the freezer to maintain the phytosanitary state then thawed, washed and dried in the open air before planting in the bags.

2.2.3.2 Preparation of Substrates

Different substrates were prepared based on the three basic elements chosen for our experiment. The proportion of each element in the mixture varies from substrate to another as shown in the table below:

Table 1 Distribution of substrate elements on different mixtures used

Substrates	Substrate 1	Substrate 2	Substrate 3	Substrate 4
Earth (%)	80	0	55	25
Sand (%)	0	80	25	55
Peat (%)	20	20	20	20

To understand the effect of the substrate on germination and growth, control substrates consisting of a single element were used sand-based substrate (100%) and soil-based substrate (100%).

2.2.3.3 Preparation of Planting Bags

We used a total of 180 planting bags, with 30 bags per substrate type; each bag was filled with 15 units of substrate (three quarters of the bag). Every bag was identified by a plastic label with the substrate type, site and repetition number. The bags were divided equally on the two experimental sites.

2.2.3.4 Seeding

A direct showing of the seeds in the substrates was carried out in a 2 cm centered planting hole, so that the pointed part left from the top, while the circular end left from the bottom. Manual watering of 100 ml of water follows the sowing. Subsequently, watering becomes daily (3 days/ week).

2.2.4 Monitoring of the Experiment

The experimental devices mounted in the two experimental stations were monitored daily with the aim of regularly recording the values relating to germination and growth parameters.

We tried to ensure the maximum favorable conditions for the development of seedlings as temperature and relative humidity. All seeds used in this study were clearly healthy and disease-free.

2.2.4.1 Monitoring of Germination

After planting avocado pits, we followed up regularly every two days by observing the planting bags at both sites to determine the rate (expressed as a percentage) and germination time (number of days) for each treatment. We, therefore, carried out a count of the two leaves seedlings and the number of days that put each seed to germinate.

2.2.4.2 Monitoring of Growth

We followed during the period of our experimentation the growth of the aerial part of the avocado seedlings. Therefore, biometric measurements of the aerial parts were carried out regularly (Daily) namely: the length and diameter of the main stem, the number of young branches and the number of leaves.

2.2.5 Data Processing and Analysis

The data collected on germination and growth parameters of the aerial part of avocado seedlings ,were the subject of a quantitative study by converting the values expressed in average and percentage to graphs, to be able to identify the difference between the experimental treatments performed; and a statistical study by analysis of variance using software - Graph Pad Prism- at the probability threshold of 5%; in order to be able to highlight the significance of the difference between treatments.

3. Results

3.1 Substrate Effect on Germination of Avocado Seeds (*Persea americana* Mill)

3.1.1 Date of Appearance of Seedlings

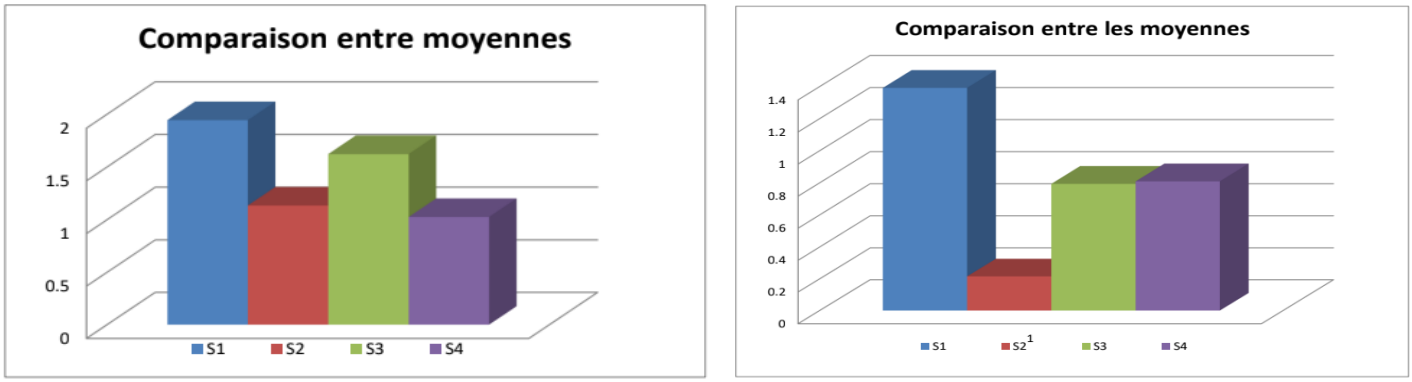
The obtained results from the two experimental trials show that uncontrolled growing conditions in the botanical garden delay germination in avocado (*Persea americana* Mill). The average germination time and latent shelf life differ depending on the type of substrate.

The best results were obtained with greenhouse seeds where conditions were well controlled and more favorable. The analysis of the results also showed the significant effect of the substrate on seed germination; we found that the best germination was obtained in seeds placed in the substrate composed of 80% earth and 20% peat.

3.2 Substrate Effect on Growth of Avocado Seedlings (*Persea Americana* Mill)

3.2.1 Height of Stem

The obtained results of the stems height evolution of young avocado seedlings in the different substrates of the two tests are well illustrated in the figures below:



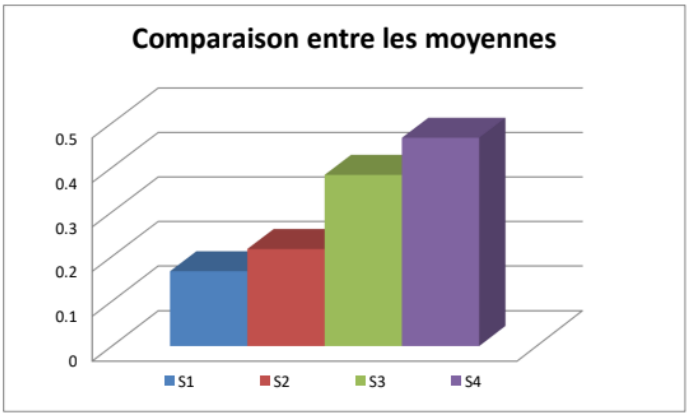
Serre (1) Jardin botanique (2)

Fig. 1, 2 Mean stem height of seedlings of the four substrates of the two tests

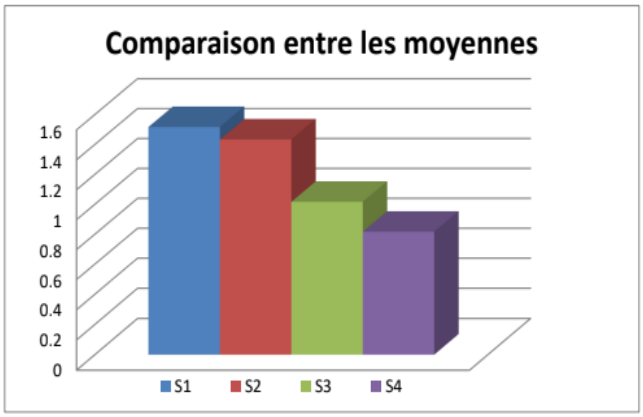
The reading of figures 1 and 2 and the results of the statistical analysis show that the height of the stems was significantly important in the seedlings greenhouse in the substrates: S4 composed of 55% sand + 25% earth + 20 peat and S3 composed of: 55%earth+25% sand + 20% peat; with respective averages of: 3.73 cm and 2.15 cm. The main stem height growth values were less important in the botanical garden test but the substrate effect was of the same significance.

3.2.2 Number of Branches

The differences in the number of branches emitted by the main stem recorded between the different substrates at the two experimental sites are illustrated in Figures 3 and 4.



Serre (3)



Jardin botanique (4)

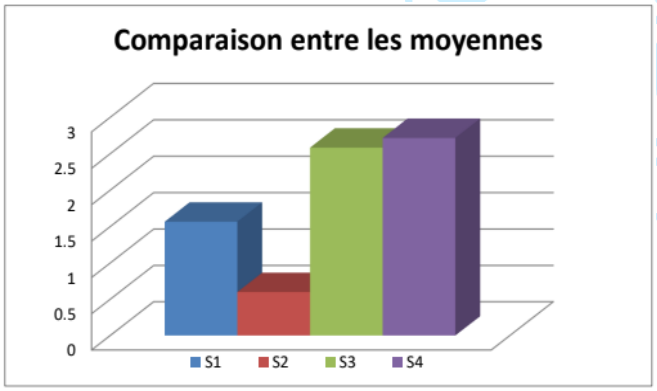
Fig. 3, 4 Mean number of seedling branches of the four substrates of the two tests

We found that the effect of the substrate on the growth and development of the aerial part in the studied species is significant. The analysis of the data shows that the number of branches emitted varies from one type of substrate to another in the two experimental sites, the most representative of which was that obtained in plants grown in substrates S1composed of: 80% earth + 20% peat and substrate S4constituted of: 55% sand + 25% earth + 20% peat.

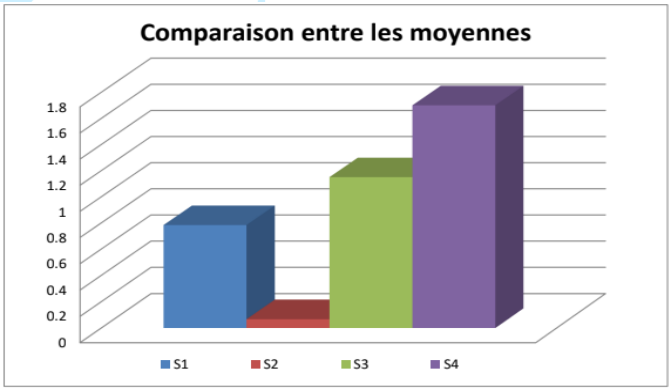
The comparison of the results of the two sites revealed the superiority of the values obtained in seedlings raised in greenhouses compared to those recorded in seedlings of the botanical garden. Indeed, the average number of branches of the seedlings of the greenhouse was respectively for the substrates S1 and S4 of the order (1.52) and (1.4), while this average was for the same substrates of the order of (0.16) and (0.21) in the plants that grew in the botanical garden.

3.2.3 Number of Leaves

The mean values of the number of leaves per main stem recorded in the seedlings of the different substrates and in the two experimental sites; are shown in figures 5 and 6.



Serre (5)



Jardin botanique (6)

Fig. 5, 6 Mean number of seedling leaves in the four substrates of the two tests

The analysis of the results illustrated in Figures 5 and 6 shows that the number of leaves of young avocado seedlings is significantly affected by the type of substrate and the surrounding biotope.

For the botanical garden, the best results were those recorded in young plants raised on S4constituted substrates of the following proportions: (55% sand + 25% earth + 20% peat) with an average of (2.72) and S3 consisting of: (25% sand + 55% earth + 20% peat) with an average of (2.58).

For the greenhouse, the maximum average number of leaves per tigelle was that recorded in plants grown on the same substrates S4 and S3with respective values in the order of: (10 .7) and (6.75).

Statistical analysis also revealed a remarkable positive effect of the type of biotope and substrate on leaf production in seedlings.

4. Discussion

The greenhouse has the best germination results, as it has sprouted many seeds compared to the botanical garden. This is explained by the controlled climatic conditions in the agricultural greenhouse, such as humidity (H°) and temperature (T°), which promote the germination of avocado seeds.

The S1 substrate, composed of 80% soil and 20% peat, promotes better germination of avocado seeds. This can be explained by the basic elements presented in the substrate mixture. During the germination phase, the seeds are sensitive due to the physicochemical properties of the substrate components, which affect its physical quality.

Substrates S3 (55% soil, 25% sand and 20% peat), S2 (80% sand and 20% peat) and S4 (55% sand, 25% soil and 20% peat) also encourage germination, but somewhat slower than the S1 substrate. This can be interpreted as due to the quality of the substrate, which is an essential parameter for favorable seed germination. The absence of seed germination may be caused by death or deterioration of the seed or a part thereof.

Our study allowed to know the effect of different mixtures of substrates on the development and growth of avocado seedlings; however, the evolution of the stem height of (*Persea Americana* Mill) plants shows that the behavior of these plants in relation to the substrates studied is different.

The substrate composed of (80% earth and 20% peat) and the substrate composed of (55% sand, 25% soil and 20% peat) seem to be a preferable adaptation in height of the young seedlings of the avocado; this can be explained by the basic elements contained in these mixtures; while the plants are sensitive in the early stages of growth, which is granted to the physicochemical property of the components of the substrates.

The substrate type parameter has a direct effect on the number and surface area of the leaves of the seedlings of the studied species. (Hamidi et *al*., 2017); the extended effect on the latter is observed in the S4 substrate (55% sand, 25% earth and 20% peat), which is explained by its porosity, aeration and water and mineral ion retention capacity.

According to previous studies, a good substrate should be composed of a basic aerating element and a basic retaining element. According to (Sbay and Lamhamedi, 2007), the proportion of organic matter in the substrate must be relatively high (>60% by volume) to guarantee good water retention capacity and good cation exchange capacity, which will also favor the retention of mineral elements-it is the case in our substrate- that consists of a mixture of (55% sand, 25% earth and 20% peat).

In addition, leaf area and number of leaves are linked to photosynthetic activity and transpiration area (Bensighir-Boukhariet Argillier, 2006). The increase in leaf area and number of leaves in certain substrates shows that there is a significant effect of natural basic components on these; and the use of natural basic components in different proportions gives maximum growth and development in the number and area of leaves. The control (100% sand) promotes good seedling growth; however, at a slower rate.

5. Conclusion

This work is intended to evaluate the effect of different substrates on the growth of plants of the exotic species avocado (Persea Americana Mill). Our results show the interest of the use of certain mixtures of substrates with different fractions; which favor a better development of the seedlings.

From this work, we realized that a substrate constituting the different natural basic elements can promote the physico-chemical properties. This is reflected in improved germination conditions as well as the growth and the development conditions of the plants of the species under study.

The obtained results show that the substrate composed of the mixture (80% earth + 20% peat) and that composed of (55% earth + 25% sand + 20% peat) seem to be the most favorable for a better development of young avocado plants; however, the multiplication of avocado plants in a 100% sand substrate can promote seed germination but at a slow rate; this process can be recommended to nurserymen, due to being inexpensive and simple to perform.

The number of leaves per plant in bags containing a mixture of soil and sand is low compared to other substrates. The increase in the number of leaves significantly affects the development of seedlings following the improvement of photosynthetic activity and transpiration. High oxygen levels and high humidity in the substrate can promote better root development and rapid growth of seedlings.

The soil/sand substrate is the best mix to multiply avocado; it contains an aerator base element and a retentive base element, which promotes good water retention capacity and good cation exchange capacity thatwill promote the retention of mineral elements.

However, it would be recommended to study other sources of culture substrate mixtures and other proportions for a quality culture substrate and which will be a prime index for the production of a quality nursery plant.

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