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PHYSICAL CHARACTERIZATION OF THE FRUIT, GERMINATION CAPACITY AND GROWTH IN THE NURSERY OF THE: *Moringa oleífera* Lam, UNDER FOUR SUBSTRATES IN THE MUNICIPALITY OF TURBO ANTIOQUIA

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Abstract: Due to the promise of the Moringa oleífera Lam sample, in the area of Urabá and the municipality of Turbo for animal and human nutrition and the ecosystem services of the plant, an investigation was carried out that characterized the fruits and evaluated reproductive characteristics (germination). and vegetative in the nursery stage. This evaluation was carried out on isolated trees that were found and that can serve as a seed source for the propagation of the species in the territory. The study trees (4) were georeferenced and 20 silique-type fruits were collected from them to finally select 10 of each. In the characterization phase, the variables total fruit length, fruit diameter, total number of seeds, seed diameter and seed weight were studied; In the nursery phase, the variables germination, root length, plant weight and plant length were studied. Analysis of variance was applied to the data obtained at a level of ($p \leq 0.05$). When significant differences were found, a Tukey test was performed. In the characterization phase, statistically significant differences were found in the fruit length variable and in the nursery phase they were found in the root length, plant weight and plant length variables, indicating that the physical characteristics of the fruits and the reproductive characteristics of the evaluated trees allow a multiplication of the species equal to that which has been reported in other studies. Based on these results, it is convenient to carry out other studies related to the growth in the field of the species and the evaluation of the products and by-products that are obtained for the different fields of interest.
Keywords: Agroforestry, tree, food product, soil, humid tropics.

INTRODUCTION

Plants are very important for man's life since food, medicine, raw materials, among others, are obtained from them to meet various needs of daily life, as is the case of Moringa oleífera Lam, native to the southern Himalayas, India, Pakistan, is the best known species of the Moringa genus with more than 13 species. It reaches 7-12 m in height and 20-40 cm in diameter, with an open umbrella-like crown and a straight bole. The leaves are compound and are arranged in groups of leaflets with 5 pairs arranged on the main petiole and one leaflet at the terminal part. The leaves are alternate tripinnate with a length of 30-70 cm Godino (2014).

In the same way, Godino (2014) mentions that it is a perennial tree, but with a short life of approximately 20 years. It is a very fast-growing species that provides a significant amount of nutrients to the soil, in addition to protecting it from external factors such as erosion, desiccation and high temperatures; the flowers are bisexual with white petals and yellow stamens; the fruits are linear, 3-sided brown capsules with longitudinal grooves, 20-45 cm long, although sometimes 120 cm and 2-2.5 cm wide, the seeds are dark brown, 1 cm globular in diameter with wings with a papery consistency.

Taking into account the above, it is important to refer to the outstanding characteristics of this plant exposed in the works of Fugliee (2000) and Russo, (2000) who show the great potential for use in green manures due to the large amount of nutrients it provides in the animal diet and its excellent conditions to extract nutrients from the soil, which implies considering fertilization at the time of cultivation; Foidl et al. (1999), Munoz et al. (2008) and González et al. (2006), For water treatment, in which the effectiveness of Moringa seed powder has been demonstrated to treat wastewater from agricultural production processes such as coffee and vegetable peeling, especially in parameters such as turbidity, pH and the chlorides; Garavito (2008), Corella (2010)

and Becker & Nair (2004) for the production of ethanol, works in which it is evident that the concentrations of cellulose, Hemicellulose and lignin in different media allow obtaining a significant amount of fuel product.

The aforementioned makes a study important and necessary to determine the agronomic behavior of this species under the environmental conditions of the Urabá area and especially the municipality of Turbo since its characteristics of life zone and tropical forest are similar to the zone of origin, so the study of this plant is of great relevance for the scientific community, local producers and the community in general due to the great potential that has been identified and the amount of products and services it can provide, especially to communities less favored.

On the other hand, the species M. oleífera Lam has been observed in the Municipality of Turbo, which, without being native, is reproduced on a small scale (only isolated trees) without the owners of the trees having agronomic knowledge of them. especially on the characteristics of how to characterize the fruits and seeds, reproductive processes, productive aspects, chemical characteristics of their parts, market aspects of derived products, among others. Therefore, the interaction of some strategies that, following the scientific method, facilitate the generation of knowledge about the species M. oleífera Lam is convenient, in order to contribute significantly to a comprehensive study aimed at generating technological packages produced in the area of Urabá and the municipality of Turbo for its use in the different uses registered for this species by authors such as Fuglie (1999), Tee et al, (1997), Alfaro & Martínez (2007) among others.

In accordance with the above and taking into account that, in the Urabá area, in the municipality of Turbo Antioquia there is no evidence that this species is cultivated, it is necessary to carry out characterization and propagation studies to recognize the response of the seed under the use of substrates that allows the best growth of the seedling in the shortest possible time. Therefore, the general objective of the research was to determine the physical characteristics of the fruits of 4 isolated trees and the determination of the germination and growth capacity in the Moringa oleífera Lam nursery, under four substrates in the municipality of Turbo while the Specific Objectives were to recognize the physical characteristics of fruits and seeds of M. oleífera Lam; determine the germination capacity of M. oleifera seeds under the treatments; T1 rice husk 75% + sand 25%, T2 wood debris 75%+ sand 25%, T3 Sawdust 75% + sand 25%, T4 Witness (earth) 100%; identify the best substrate for the germination of M. oleífera in the municipality of Turbo and recognize the best substrate for growth in the nursery stage between treatments.

It is important to mention that among the background is that in the study carried out by Medina et al (2007) physical properties of M. oleífera Lam are compared with other species used as forage such as leucaena leucocephala cv, cunningham, in which it is found that Variables such as germination in the nursery, diameter of the stem and branches, the length of the branches and the number of leaves per branch did not show significant differences in relation to the treatments used. In relation to the growth in the nursery, the study concludes that the plants can be taken to the field from week 7.

On the other hand, the research of Villarreal et al (2014) aimed at evaluating four fertilizers based on Nitrogen, Phosphorus and Potassium, (NP K) and ammonium and nitrate solution (NPK), to promote their growth and development, finds that the The highest growth rate was obtained with the NPK

treatment with an average monthly growth of 14 cm, and the lowest was recorded with the N, (10.7) and K, (10.95 cm) treatments. The analysis of variance showed highly significant differences for said growth ($p \leq 0.01$), while the treatment with phosphorus presented an intermediate average growth of 12.4 cm per month.

Likewise, there is the work of Pérez & García (2010), which consisted of sowing scarified and unscarified M. oleífera seeds, for which two consecutive experiments were carried out. In experiment 1, a total of 75 black polyethylene bags of 1 kg capacity were used for each treatment, which were filled with a mixture of 70% clay and 30% earthworm humus. Sowing was carried out by depositing a seed 2 cm deep in both treatments, after sowing and every three days the bags were irrigated until the saturation point. In this work it is found that the scarification of the seeds showed a significant increase in the emergence of the seedlings in both experiments, so that, ten days after sowing, 96% of the fertile seeds germinated, while the non-scarified fertile seeds they completed their germination 17 days after sowing in experiment 1. Likewise, in experiment 2, at 13 days after sowing the non-scarified seeds exhibited 40% fewer seedlings than the scarified ones. The scarification treatment showed a higher growth rate (5.76 mm/day) of the seedlings than in the treatment without scarification (4.14 mm/day) in the experiment. The results obtained from this investigation showed that the germination of scarified seeds were 55 and 43 mm higher than the germination of non-scarified seeds.

On the other hand, the study by Vázquez & Pérez, (2013) which consisted of sowing 14 batches of 40 M. oleifera seeds each, at intervals of 15 days between each one, each batch was placed in plastic boxes, they were identified with capital letters from A to N, and each bag within the lots was numbered from 1 to 40, the sowing of each of the lots was carried out in transparent polyethylene bags of 7.5 cm in diameter and 30 cm high (1,325 cm3), in a substrate based on a mixture of peat, vermiculite and fertilizer (70% peat, 22% vermiculite and 8% fertilizer), then the seeds were selected based on color and the size, they were treated, prior to their planting, keeping them soaked for 24 hours, to hydrate them and accelerate their germination, the planting was carried out by introducing the seeds into the substrate to a depth of 1.5 cm, during the study time they were They measured the temperature and relative humidity, by means of a sensor placed, both in the nursery and in the Greenhouse. From this investigation, the most relevant results were the evident sensitivity of M. oleífera to sudden variations in temperature, especially if these occur in short periods of time, in addition to environmental circumstances, there were a series of problems related to the appearance of diseases and pests during the development of the cultivation of M. oleífera, both in the greenhouse and in the nursery, which will be necessary to take into account in the development of plant production works, highlighting the high percentage of seeds that finally did not germinate, due to below 75%.

MATERIALS AND METHODS

LOCATION

The study was carried out in the municipality of Turbo, which limits to the north with the Caribbean Sea and the municipality of Necoclí; to the east, with the municipalities of San Pedro de Urabá and Apartadó and with the department of Córdoba; to the south with the municipalities of Carepa, Chigorodó and Mutatá, and to the west with the department of Chocó (Turbo Municipality, 2012). It has a warm humid climate, presenting rainfall distribution throughout the year without

presenting a marked dry season despite the fact that the period of least rainfall is between the months of December and April. It has average temperatures above 24ºC and annual rainfall between 2,000 and 2,500 millimeters, generated mainly by the presence of the low-pressure system anchored in Panama that remains active for most of the year with an internal pressure of up to 1,005mb in the wet season and in dry season of 1010mb (DANE, 2014).

The experiment was carried out with randomly distributed trees, taking into account that in the municipality there are no crops of the species and its origin and planting methods are unknown, they were located at the coordinates shown in Table Number:1

Type of investigation and phases.

The investigation carried out is of an experimental type consisting of the realization of different phases which were:

Individualization of trees and georeferencing: With the help of a Garmin Etrex-20 GPS, the georeferencing of 4 trees in the municipality that were in the reproductive phase, bearing ripe fruits and suitable to be used, was carried out. The obtained coordinates were loaded into Google maps to schematize the position of the trees. trees on the territory.

Obtaining fruits and characterization: From the individualized trees, 20 fruits (silicua type) were obtained from each one of them for a total of 80 fruits packed in separate bags and labeled with the geo-position of the tree to be analyzed. Later, 10 siliques were selected from each bag to analyze the results. parameters showing Table Number:2

Description of instruments and equipment: The georeferencing of trees was carried out with a Garmin eTrex-20x GPS; To determine the weight of the silique, a SCOUT brand portable electronic scale was used. PRO-MODEL SPU601 with precision to grams; silique measurements were made with a GRIPPER flexometer against impacts with a length of 5 m (16 ft) and a width of 3/4 PG and silique diameter measurements were made with a MITUTOYO caliper made of metal with maximum measuring range 150 mm.

GERMINATION EVALUATION

For the preparation and composition of the substrates, 75% decomposed substrate of matter (rice husk, wood debris, Sawdust) and 25% washed sand were used, meanwhile the Witness used was normal earth known as earth of 100% hood.

Next, a disinfection was carried out, using 10 cm of formaldehyde for each liter of water, this way 4 liters prepared for each of the substrates were used; Subsequently, each of the substrates was covered for four days with black plastic, to obtain greater disinfection and elimination of pathogens, stored in a covered place, but without walls at room temperature at approximately 30 ºC. Subsequently, the germinators were filled for each of the substrates, taking into account the fruits of the seeds in the upper left and lower right and center ends, supplying 20 seeds in the center and 10 seeds in the ends for each substrate, the which were extracted from the siliques characterized in phase I that were already classified by identified tree, the amount of seeds used for germination was due to the amount of material available and the culture media since no bibliography was found in this regard. abundant and in this phase it was measured in percentage of germination from day 3 when the first emergence was observed until day 15 when it was considered that it had stopped.

SEED PLANTING

For the sowing of the seeds, the date to be sown in the plastic germinators was taken into account, the seeds were classified, size,

Tree number:	Coordinate Number:	Coordinate: W	Height: S.N.M
Tree Number:1 La Martina Turbo Sector	N 8° 10.305'	W 76° 44.101'	6
Tree Number:2 San Martín Sector	N 8° 07.978'	W 76° 42.832'	18
Tree Number:3 San Martín Sector	N 8° 07.974'	W 76° 42.834'	16
Tree Number:4 Baltazar Sector	N 8° 05.801'	W 76° 43.441'	11

Table Number:1 Georeferencing of evaluated trees

Parameter	Unit of measurement	Measuring instrument
Total length of the fruit	Cm	flexmeter
fruit diameter	Cm	calibrator
total number of seeds	No	-
seed diameter	Mm	calibrator
seed weight	Gr	Balanza

Table Number:2. Variables measured in the fruit of *M. oleífera* Lam

Own source

Parameter	Unit of measurement	Measuring instrument
Germination	Unit	-
root length	Cm	flexometer
plant weight	Gr	balance
plant length	Cm	flexometer

Table Number:3. Variables measured in plants *M. oleífera* Lam

Source: Own construction

Variable	*F*	Probability	Decision
Fruit length	5,69977261	0,007510123	*
fruit diameter	0,37209302	0,774240593	-
Number of seeds per fruit	1,29459735	0,310406108	-
seed weight	2,19402985	0,130945468	-
seed diameter	1,46708464	0,248401079	-

* Significant difference

Table Number:4. Summary statistical behavior of fruit characterization variables of *Moringa oleífera.*

	Tree 1	Tree 2	Tree 3	Tree 4
Tree 1		-4,1*	-3,56	-5,1*
Tree 2			0,54	-1
Tree 3				-1,54
Tree 4				

* Significant differences

Table Number: 5 significant differences for fruit length

quality, including the upper and lower ends and the center of the fruit, then the sowing was carried out. from the seeds to a depth of 2 cm and a distance between seeds 2 cm. When the seedlings were 19 days old in the sprouters, the transplant was carried out in a polyethylene bag, this because their size began to show high competition and overturning in the sprouter, they were filled with two kilos of substrate, previously a measurement was made of the length of the plant and its weight to five seedlings for each substrate and for treatment before transplanting, these taken at random.

SEEDLING GROWTH EVALUATION

This phase was developed by taking growth data in centimeters every 8 days for a period of 2 months for a total of 8 measurements of the plants that were in each substrate, measuring 10 plants of each repetition, of a variable amount between 24 and 40 germinated plants in the repetition, a total of 30 plants per treatment were measured.

In this phase, the variables were measured according to Table Number:3

Data treatment.

The data obtained were treated by means of descriptive statistics, initially applying means and sums of squares to know the behavior of each factor in the block and later applying analysis of variance to know if there was a significant difference in the treatments and in the cases where said difference was found, Tukey's test was applied to determine the treatments where said differences occurred at 95% confidence ($p \leq 0.05$) using the formula:

HSD=Qr (CME within groups/ n)0.5. Where:

HDS: Honestly Significant Difference

Qr= multiplier

CME= square of the mean error within the groups

n= sample size in each of the groups

The variance analyzes were performed with the statistical program Statgraphics XVII.

RESULTS AND DISCUSSION

Characterization of Moringa oleífera fruits. The results and discussion of the variables obtained in the characterization phase of the fruits of the four trees evaluated are described below, taking into account the results obtained in the analysis of variance shown in Table Number:4.

Fruit length. The evaluation of the length of the fruits showed that tree Number:1 presented an average length of 40.2 cm, for tree Number:2 the average corresponded to 36.1 cm, for tree Number:3 the average of the fruits was of 36.64 cm and for tree Number:4 the average of the fruits was 35.1 cm. The length of the fruits when subjected to an analysis of variance (ANOVA), showed that there are statistically significant differences as can be seen in Table Number:4 therefore, when performing the Tukey test, it was established that said differences were found when comparing the fruits of tree Number:1 with the fruits of tree Number:2 and the fruits of tree Number:1 with the fruits of tree Number:4 as shown in Table Number:5.

The minimum average of the evaluated fruits corresponded to tree Number:4, which has an urban location, and the one with the highest average was tree Number:1, which is located on the outskirts of the city and very close to the sea, conditions that may be more favorable for the development of these since it is difficult to attribute this difference to environmental factors due to the proximity between them which does not exceed 10 km and their height above sea level is similar. However, the size obtained is within the ranges of different studies among which Ramos et al. (2010), Fitomed (2010), Pérez et al (2010), who found a maximum size of 40cm, while Ledea et al (2018) reported a maximum size

of 46cm, as did Csurhes and Navie (2016) and finally, exceptional size is reported by Paliwal et al. (2011) who found fruit length up to 120cm.

Fruit diameter. The diameter of the fruit showed an average of 2cm for tree Number:2 as the highest average and 1.92 for trees Number:1, Number:3 and Number:4 as. When the analysis of variance was applied to the data, it was found that there is no statistically significant difference between them.

Regarding the diameter of the Moringa oleifera fruits, no representative variations were recorded, considering for this study that the values found are within the range recorded by Olson & Fahey (2011), who report that the diameter of these fruits is between 1, 5 and 3cm.

Number of seeds per fruit.

The number of seeds per fruit showed that the highest number is presented by tree Number:1 with 20.8 on average, followed by tree Number: 4 with 18.2, tree Number:2 with 18 and finally tree Number: 3 with 17.6. When performing an analysis of variance of the data, it was found that there is no statistically significant difference.

The number of seeds per fruit indicates that although tree number 1 has a higher number of seeds, this does not represent a significant difference with the other trees evaluated, possibly its location outside the urban sector may be influencing this situation, however, as soon as Regarding the number of seeds per fruit, other studies do not find a statistically significant difference for this variable, as is the case of those reported by Ledea et al. (2018), Ramos et al., 2010) and Gonzalo (2016), where sata 20 seeds are reported. per fruit as a maximum average in which it coincides with this study.

Seed weight. The behavior of the average weight of the seed shows that trees 2 and 3 present an average of 0.4gr, while trees 1 and 4 have an average of 0.3gr. When submitting the data to an ANOVA, it was found that these do not present a statistically significant difference.

Regarding the weight of the seed, it is found that in general it is among what has been disseminated by the few studies that this variable has had, in this regard Ayerza (2011) and Ogunsina (2006), present studies that relate the size with the weight of the seed finding that the values found in this study correspond to normal to high values.

Seed diameter. The average diameter of the seeds of the evaluated trees shows that tree Number:3 presents an average of 10.6mm, tree Number:2, presented 10.4mm, tree Number:4 presented 10.1mm, while in trees 1 presented 9.3 mm. When submitting the data to an ANOVA, it was found that these do not present a statistically significant difference.

In relation to this variable, there are very few studies that can be found despite the fact that this is very important when evaluating the productivity of oil, in this sense the values found in this study are in accordance with those reported by González (2018) who reports that the diameter of the Moringa oleifera seed is between 8 and 15mm.

EVALUATION OF GERMINATION AND GROWTH OF SEEDLINGS IN THE NURSERY

The analysis of variables in the nursery stage shows that the germination variables did not obtain a statistically significant difference, while root length, plant weight and plant length did present a statistically significant difference, this with a probability of 95 % as can be seen in table No 6.

Germination percentage: The germination variable by substrate used shows that the highest germination average was obtained when using the Witness (normal soil from the upper part of the soil) with a percentage of

68.3%, followed by the husk of rice with sand that presented a germination percentage of 63.3% and finally the substrates wood debris with sand and sawdust with sand presented an average of 56.7%. When carrying out an analysis of variance of the data, it was found that there is no statistically significant difference, despite which these germination values can be considered as low compared to those registered in other studies such as those of Alfaro & Martinez (2008) who report values higher than the 80%; Sharma and Rains, (1982) who reports values up to 90% and Valdez et al (2018) with values of 85%, all in substrates composed of upper layer of soil or sand; however, if there is an interest in the area to propagate this species by seed, the values found are appropriate to achieve it without having to resort to importing it.

Root length. Regarding the length of the root, it was found that the plants that germinated in the husk substrate of rice with sand presented an average of 20.8 cm, the Sawdust substrates with sand and wood debris with sand presented averages of 7.64 cm and 7 cm respectively, while the Witness substrate presented an average of 4.88 cm as observed in figure Number: 1

When carrying out an analysis of variance of the data, it was found that there is a statistically significant difference and when applying the Tukey test, it was found that the differences were between the husk treatment of rice with sand when compared with the Witness, Sawdust with sand and wood treatments. debris with sand as shown in Table Number:7.

The length of the root when rice husk with sand was used as a substrate presented a larger size, possibly due to the physical characteristics of this substrate, which presumably presents a greater pore space and temperature, stimulating root growth.

Plant weight: When carrying out the weight of the complete plant, it was found that the plants of the wood debris substrate with sand presented an average weight of 3.62gr, the control substrate plants presented an average of 2.24gr and the plants of the husk substrates. rice with sand and sawdust with sand presented averages of 1.92gr and 1.66gr respectively, as shown in figure Number:2

When carrying out an analysis of variance of the data, it was found that there is a statistically significant difference and when applying the Tukey test, it was found that the differences were between the treatment of rice husks with sand when compared with the control treatments, sawdust with sand and detritus. of wood with sand as shown in Table Number:8.

The total weight of the plant shows that the rice husk substrate with sand achieves a difference in relation to the other treatments used, which is consistent with the larger size that the plant obtains.

Plant length. In relation to the total length of the plant, it was found that the treatment with wood debris presented an average of 21.6 cm, the rice husk treatment with sand presented an average of 20.8 cm, the control treatment presented an average of 19 cm. 7cm and the sawdust treatment with sand presented an average of 17 cm as shown in figure Number:3.

When performing an analysis of variance, it was found that there were statistically significant differences, so the Tukey test was advanced, establishing that these differences occur when comparing the rice husk treatment with sand with the control treatments, sawdust with sand and debris. of wood as shown in table Number: 9.

Regarding the size of the plant in the nursery, there are no published studies from academic sources, however, the averages found are adequate for the establishment of a plantation without any technical problem.

Variable	*F*	Probability	Decision
Germination	0,240069085	0,866056079	-
root length	37,27611604	1,89612E-07	*
plant weight	52,54252874	1,14805E-09	*
plant length	165,0840149	2,82175E-14	*

* Statistically significant difference

Table Number: 6 statistical behavior of variables germination stage and growth in nursery

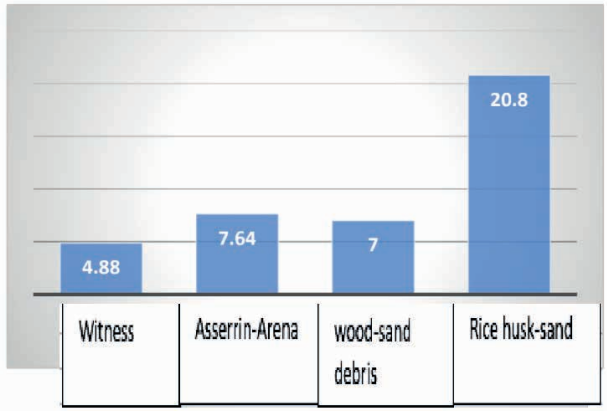


Figure Number:1 Long behavior of the root according to treatments

	Witness	Sawdust	Wood debris	Husk
Witness		2,76	2,12	15,92*
Sawdust			-0,64	13,16*
Wood debris				13,8*
Husk				

* Significant difference

Table Number:7 Significant differences for root length

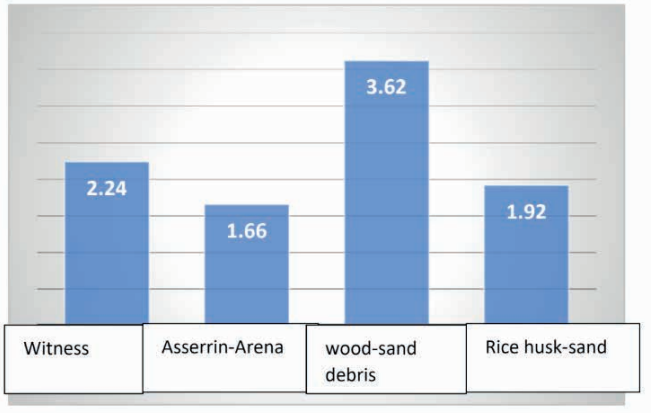
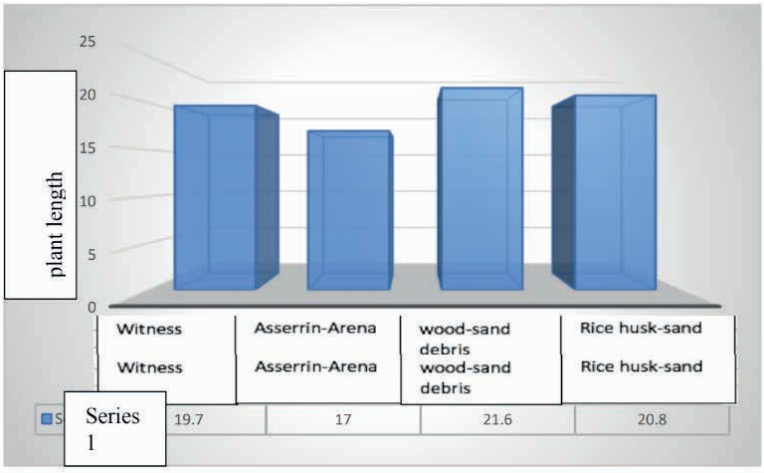


Figure Number 2 weight behavior of the plant according to treatments

	Witness	Sawdust	wood debris	husk
Witness		-0,58	1,38	-0,32*
Sawdust			1,96	0,26*
wood debris				-1,7*
husk				

* Significant difference

Table Number:8 Significant Differences for Plant Weight



Picture number3 comparative of the length of the plant by treatment

	Witness	Sawdust	wood debris	husk
Witness		-2,7	1,9	-14,54*
wood debris			4,6	-11,84*
wood debris				-16,44*
husk				

* Significant differences

Table Number 9: Significant differences throughout the plant

In general, the study shows that the evaluated trees have a production that makes them possible seed sources for the establishment of plantations in the municipality and in the region, also observing that the tree that is closest to the sea and farthest from the urban zone shows slightly better production conditions, aspect that until now has not been registered in another study.

On the other hand, the results found in the evaluation phase of germination and growth in the nursery reveal two positive aspects for the production of plants in the municipality: on the one hand, the fact that the highest percentages of germination were achieved when using the witness and on the other hand that the greatest growth of the plant in the nursery phase is achieved by using rice husks with sand, materials that are very easily found in the municipality and therefore no major investments would be generated in the process.

Finally, it would be good in future studies to carry out a larger search for possible trees in the territory and evaluate the same variables, especially that their location differs in height above sea level, type of life zone, productive system, among other aspects, and thus way to have more knowledge about the behavior of the species in the municipality and therefore more elements to disseminate its potential.

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