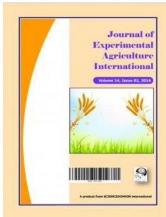

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Comparison between Planting and Sowing as Forms of Amaranthus *(Amaranthus spp.)* Propagation and Investigation of Different Seeding Depths

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MAS, AB, MSD, VSMS and RFD performed the experiment and wrote the first draft of the manuscript. The authors PSXP, PMCC and CAQG discussed the results, corrected and improved the writing of the manuscript in Portuguese and English versions. All authors read and approved the final manuscript.

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ABSTRACT

Amaranth is a broad leaf pseudocereal native to South and Central America and can be used as a source of high protein grain, as a leafy vegetable and has the potential to grow as fodder. The objective of this work was to evaluate some characteristics of amaranth agronomic interest (*Amaranthus spp*), as the best way of propagation of the crop, whether by planting of seedlings or direct seeding, and also to determine the most suitable depth of sowing of amaranth. Three

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treatments were established to conduct the first experiment, seedling versus no-tillage using the BRS-Alegria variety: the first (T1) was the planting of seedlings with 15 days old, previously produced in a greenhouse, on the day of establishment of the experiment in the beds; the second (T2) was the direct sowing in the soil on the day of establishment of the experiment in the beds; and the third (T3) was the transplanting of surplus seedlings from the first treatment, after two weeks of establishment of the experiment in the beds. The T1 treatment was the one that presented the best performance in the attributes of lap diameter and dry mass of plants, being not different, only, at plant height, in relation to T2 treatment. The treatments T2 and T3 presented the same performance for all attributes studied. The second experiment was carried out with the objective of evaluating the best sowing depth for the Amaranthus varieties: BRS-Alegria, Diócus, Princes, Verde *(Amaranthus cruentus)* and Inca *(Amaranthus caudatus)*, under zero millimeters soil), five millimeters, and ten millimeters deep. The BRS - Alegria, Verde and Diócus varieties showed the best results when tested at 0, 5 and 10mm depth, with the average of plants emerged at 15 days after sowing, of 71.4; 65.9 and 61.0 respectively. The worst results were found in the Princes and Inca varieties, with average values of emerged plants of 51.3 and 47.2, respectively. As for the seeding depths, the best were 10 and 5 mm, with plants emerged after 15 days, of 86.9 and 77.9, respectively. The worst result was for the 0mm depth with an average of 13.3 emerged plants.

Keywords: Amaranthus spp.; depth of sowing; seedlings; seeds.

1. INTRODUCTION

The genus *Amaranthus* comprises several species of dicotyledonous plants whose leaves and seeds are regularly consumed as food in several countries, among which Brazil is not included. The grains species stand out for the advantage of the rapidity of growth and production, allowing the cultivation under conditions of scarcity of moisture in the reproductive phase. Given its noble nutritional characteristics, this grain presents itself as a naturally balanced food with functional food properties [1]. With the increasing demand for fitness products amaranth has its place of prominence, in addition to vitamins and minerals presents high protein content ranging from 14 to 16.6% [2].

Amaranth can be used in soil protection and as forage, in the off-season. Numerous foods can be produced to meet the demand for special diets such as flours, breakfast cereals, pasta, gluten-free biscuits; are useful for people seeking alternatives to animal protein, cholesterol-free, and celiac patients. In pork and poultry feed, it has an advantage over corn or soybean alone, as a source of high biological value protein [3]. Amaranth is also a very resistant plant, presents good tolerance to water shortage and high temperatures [4], making it easily adaptable to sites with these characteristics.

Seed depth is a highly important factor, since it is related to germination and emergence of seedlings, which guarantees the obtaining of a good stand of homogenous plants [5]. Exaggerated seeding depths may make it difficult for the seedling to emerge at the soil surface, as well as reduced depths, increase the seed's vulnerability to any environmental variation, such as excess or water or thermal deficit, resulting in small and poorly grown seedlings. Thus, adequate sowing should be achieved at a depth that facilitates nutrient absorption and plant support, ensuring rapid and uniform germination with minimal reserve expenditure [6].

To opt for sowing or planting pre-prepared seedlings, is a decision that varies depending mainly on the history of the crop and its physiological behavior. In both cases, there will be advantages and disadvantages resulting from this choice. In forest species, according to [7] it is possible that the packaging (container carrying the seedling) increases the chances of obtaining early senescent plants, as a consequence of root folding. However the production of more uniform plants, as well as the greater number of plants per unit area, is examples of advantages of this system. Seed losses are frequent in the sowing (due to poor regulation in the distribution equipment, pest and disease attack) and start on the sowing day and continue until the germination period has ended. However, it is a relatively simpler and more immediate process. An important prerequisite for the success of direct seeding is the use of good seeds that have been well stocked, stratified and treated with repellents against birds and rodents [7].

The objective of this research was to evaluate some characteristics of amaranth agronomic interest (*Amaranthus spp*), as the best way of propagation of the crop, whether by planting of seedlings or direct seeding, and also to determine the most suitable depth of sowing of amaranth.

2. MATERIALS AND METHODS

2.1 Experimental Site Description

Two experiments were carried out in this work. The first experiment to be carried out was the comparison of direct seeding versus planting of seedlings in the production of amaranth seeds. Three open-air beds located in the premises of the Faculty of Agronomy and Animal Science (FAAZ) was used, each one 3.95 m long and 1.20 m wide. The experimental design in randomized blocks (DBC) was the chosen one for this experiment, to avoid differences in luminosity on the plots, since the beds have proximity of trees. Of the three flower beds used two of them contained one block each, and the third contained two blocks, totaling four blocks. Three treatments were established for conducting the test. The first (T1) was the planting of seedlings with 15 days old, previously produced in a greenhouse, on the day of establishment of the experiment in the beds. The second (T2) was the sowing on the day of establishment of the experiment in the beds. The third (T3) was the transplanting of seedlings at 15 days of age, after two weeks of establishment of the experiment in the beds.

The seedlings were produced in trays, in a nursery located in the Faculty of Agronomy and Zootechnics - Federal University of Mato Grosso (UFMT), and the substrate used was a mixture composed of 3 parts of animal manure plus straw for a part of soil, where the amaranth was sown. For the transplanting of the seedlings to the beds at pre-established time, 20 specimens of the trays were randomly selected for each treatment within the blocks. The same amount of plants was adopted for sowing treatments. Thus, at 15 days after sowing, the sowing plots were thinned and the vigorous plants removed in the thinning were used to establish the plots of the third treatment. The adopted spacing was 10 cm between plants and 45 cm between rows of plants.

In this experiment, the objective was to evaluate the best type of establishment of *Amaranthus cruentus* cv. BRS Alegria, comparing direct sowing and planting of seedlings. At 57 days after the establishment of the experiment, 10 plants of each treatment with 4 replicates (blocks) were sampled, totaling 40 plants per treatment. Measurements were made of the diameter of the colon (basal region of the stem close to the surface) and length of all the plants sampled. Afterwards, they were chopped, packaged in paper bags, identified by block and treatment, and put to dry in a forced ventilation oven at 60°C for 48 hours. Subsequently, the samples were weighed, and the weight of the dry mass was determined.

The second experiment was carried out with the objective of evaluating the best sowing depth for the Amaranthus varieties: BRS-Alegria, Diócus, Princes, Verde *(Amaranthus cruentus)* and Inca *(Amaranthus caudatus*). A randomized block design (DBC) was used to distribute the treatments. The treatments selected consisted of three different depths of sowing, the first being at zero millimeters (at the soil surface), the second at five millimeters, and the third at ten millimeters at depth. It was used three blocks distributed in a bed. A total of 45 experimental units resulted.

A plot was chosen in the premises of the Faculty of Agronomy and Zootechnics - UFMT, with measures of 3.95 m long by 1.20 m wide. At the same time, the seeds were separated from the five varieties of Amaranth: BRS-Alegria, Diócus, Princes, Verde *(Amaranthus cruentus)* and Inca *(Amaranthus caudatus)*. Since Amaranth seeds are small seeds, the process of weighing and storing the material to be sown in each of the 45 units, individually in plastic containers, using the precision scale measuring exactly 0.100 g of seeds per each plot. Sowing in 45 rows, spaced about 7 cm from each other.

2.2. Statistical Analysis

For statistical analysis, the analysis of variance (Test F) was performed, and the means were compared by the Tukey test, for ($p \leq 0.05$), using the Assistat software.

3. RESULTS AND DISCUSSION

3.1 Experiment 1

In the experiment of propagation forms, there were statistical differences between treatments

T1 - seedlings of 15 days, T2 - sowing and T3 - seedlings 15 days after germination (DAG), when the height of plants, the average diameter of the colon and the amount of dry mass per plant (Tukey, at a 5% probability level) (Table 1).

The results presented in Table 1 indicate that the T1 treatment was the one that presented the best performance in the three evaluated attributes, being not different only in the height of plants, in relation to the T2 treatment. The treatments T2 and T3 presented the same performance for all attributes studied. Thus, it can be stated that in the planting carried out with seedlings of 15 days after germination (DAG) the plants were able to develop better than in the treatments where the seeds were placed on the day of the experiment (T2) or seedlings, with age of 15 days after germination (DAG), but 15 days after the start of the experiment (T3). These results may be associated with the environmental conditions that the plants were submitted to, so that the growth of the seedlings produced in the nursery and transplanted with 15 days after germination (DAG) in the establishment of the experiment was favored. Protected cultivation consists of controlling at least one climatic factor such as temperature, air humidity, solar radiation and wind, bringing an increase in the productive efficiency of vegetables [8]. For plantings under field conditions, these results show that it is more advantageous to implant the field of production, with seedlings previously produced under ideal conditions for the initial growth of the seedlings.

The comparison between treatments T2 and T3 shows that, in the case of seed use for the establishment of cultivated areas, it is possible to transplant at fault sites using surplus seedlings from the field, since there was no significant difference between the height of plants, diameter of the colon or dry mass for treatments T2 and T3.

3.2 Experiment 2

In the experiment of sowing depths analysis of variance showed that there is no relationship of dependence between the varieties used and the seeding depths adopted (Tukey, at a 5% probability level). However, the behavior of the varieties and the behavior of the depths showed significant differences if analyzed separately (Tukey, at a 5% probability level) (Table 2).

Regarding the varieties, BRS - Alegria, Verde and Diócus presented the best results when tested at 0 mm depth, 5 mm and 10 mm, with the average of plants of the three blocks, emerged at 15 days after sowing, of 71.4 plants, 65.9 plants,

Table 1. Mean plant height (mm), plant diameter (mm) and dry mass (g / plant) of amaranth plants *Amaranthus Cruentus* cv. BRS Joy after 57 days of planting by seedlings or sowing. Cuiabá, Mato Grosso, Brazil

Treatment	Height plants (mm)	Lap diameter (mm)	Dry mass (g/plant)
T1 - Seedlings of 15 days	1220 A	13.3 A	28.93 A
T2- Sowing	927 AB	10.7 B	14.83 B
T3- Seedlings 15 DAG	805 B	10.8 B	11.93 B

** Averages followed by the same uppercase letter in the column do not differ from each other by the Tukey test, at a 5% probability level*

Table 2. Number of emerged plants at 15 DAS (days after sowing). Cuiabá, Mato Grosso, Brazil

Variety	Depth (mm)			Average
	0	5	10	
BRS-Alegria	18.67	87.3	108.3	71.4 A
Verde	8.67	89.7	99.3	65.9 A
Diocus	17.67	78.0	87.3	61.0 AB
Princes	9.67	66.7	77.67	51.3 B
Inca	12.00	68.0	61.7	47.2 B
Average	**13.3 b**	**77.9 a**	**86.9 a**	

** Averages followed by the same uppercase letter in the column or lower case in the row do not differ from each other by the Tukey test, at a 5% probability level* and 61.0 plants respectively, according to the order of the varieties presented. The worst results were found in the Princes and Inca varieties, with average values of emerged plants of 51.3 plants and 47.2 plants, respectively. The differences between the varieties may have occurred, depending on the germination potential of the seeds of each one, which may have been different.

As for the sowing depths of Amaranth, the best were those of 10 mm and 5 mm, with averages of emerged plants after 15 days of sowing of 86.9 plants and 77.9 plants, respectively. The worst result was for the depth of 0 mm, that is, the one in which the sowing was done in the haul, with the average of the three blocks of 13.3 emerged plants. One of the reasons to explain this discrepancy in the results may be the moisture present in the seed imbibition phases, which was lower in the seeds submitted to 0 mm of seed depth and could have been a barrier to germination. This, because even irrigating the bed with enough water, after a few minutes the infiltration in the soil occurred, reducing the availability of water at the air-soil interface, just where the surface tested seeds were. According to [9] the amaranth seeds gain water, following the typical curve of the germination phases. The seeds began to emit the radicle, visible germination, characterizing the beginning of the transition from stage II to stage III of germination, when they reached a water content around 52% wet bulb [9]. Another factor that may have accelerated the process of water loss on the surface is the high insolation on the site throughout the day, favoring losses by evaporation.

4. CONCLUSION

The planting of 15 - day - old seedlings at the establishment of the experiment, obtained the best result in height, diameter of the colon and dry mass, showing the most viable alternative to the establishment of the Amaranth culture in the field.

The varieties of Amaranth evaluated showed better germination at depths of 5 and 10 mm. So, it can be concluded that sowing in the hawk mode, whose seed will be found on the soil surface, is not the most recommended for this crop, since the initial stand of this treatment was much lower compared to the others.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Amaya-Farfan J, Marcílio R, Spehar CR. Should Brazil invest in new grains for its food? The proposal of amaranth (*Amaranthus* sp.). Food and Nutrition Security. 2005;12:47-56.
2. Capriles VD, Coelho KD, Matias ACG, Arêas JAG. Effects of processing methods on amaranth starch digestibility and predicted glycemic index. Journal of Food Science. 2008;73:H161-H164.
3. Spehar, Carlos Roberto, et al. Amaranth BRS Alegria: An alternative to diversify production systems. Pesquisa Agropecuária Brasileira, Brasília. 2003; 38(5):659-663.
4. Erasmo EAL, Domingos VD, Spehar CR, Didonet J, Sarmento RA, Cunha AM. Evaluation of amaranth cultivars (*Amaranthus spp*.) In no-tillage system in the south of Tocantins. Bioscience Journal. 2004;20:171-176.
5. Rodrigues, Daniele Brandstetter, et al. Depth of sowing in the initial development of pseudocereals. Green Magazine of Agroecology and Sustainable Development. [s.l.]. Green Group of Agroecology and Bees. 2016;11(2):182-186.
   Available:http://dx.doi.org/10.18378/rvads.v11i3.4269
6. Shanmuganathan V, Benjamin LR. The influence of sowing depth and seed size on seedling emergence time and relative growth rate in spring cabbage (*Brassica oleraceavar*, capitata L.) Annals of Botany. 1992;69:273-276.
7. Mattei, Vilmar Luciano. Comparison between direct sowing and planting of changes produced in tubets, in implantation of povoamentos de *Pinnus taeda* L. Thesis (Doctorate) - Forest Engineering Course, Federal University of Paraná, Curitiba. 1993;164.
8. Silva, Bruna Abrahão. Protected cultivation, in search of more productive efficiency; 2014.

Available:https://www.cepea.esalq.usp.br/hfbrasil/edicoes/132/mat_capa.pdf
Accessed on: 25 May 2019.

9. Martins ABN, Monteiro MA, Véra MJG, Costa CJ, Radke AK, Xavier F, Silva RNO, Moraes DM. Characterization of imbibition in amaranth seeds. Informative Abrates, Curitiba. Special issue. Abstract presented at the XIX Brazilian Seed Congress, Foz do Iguaçu. 2015;23(2).

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