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Evaluation of variables of vegetative growth of amaranth (Amaranthus cruentus L.) variety Amaranteca in the Biotechnology Laboratory, National Autonomous University of Nicaragua, Managua

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Keywords: Amaranth, Vegetative growth, UNAN Managua.

ABSTRACT

The objective of this study was to evaluate the vegetative growth variables of Amaranthus[1] cruentus L. var. Amaranteca in Managua. The cultivation was established during the months of June-September 2010, on a property located

1. Evaluation of vegetative growth variables of amaranth (Amaranthus cruentus L.) variety Amaranteca at the Center for Research in Biotechnology, National Autonomous University of Nicaragua, Managua. The study was carried out after the international project "Amaranth: The Food of the Future". Research line CNE-2.2: Food and nutritional security and sovereignty. Author: Lic. Rommel Benjamín Uriarte Ortiz; co-authors: Jorge Luis Esquivel Quezada, Dr. Martha Lorena Lacayo Romero and Martha Carolina Jarquín Pascua. Funded by Centro de Investigación en Biotecnología UNAN-Managua. June-September 2010.

in the Ricardo Morales Avilés University Campus - UNAN Managua, the experimental unit consisted of five rows of 50 m long, with the distance between plants and rows of 50 cm, 100 kg ha^{-1} was fertilized with NPK (12-30-10). A direct stream sowing system was used, the emergence of seedlings occurred after four days, and thinning, weed control, and hilling were carried out. The maximum averages in the variables were 255 cm in Height of the plant, 109 units of leaves, 29.8 cm in Length of leaf, and 4.2 cm in Diameter of the stem. Significant differences (Tukey, p> 0.05) were found between the Height of the plant and the number of leaves; Stem diameter and number of leaves; and Stem diameter and size of leaves. Keywords: Amaranth, Vegetative growth, UNAN Managua.

1. INTRODUCTION

Grain amaranth is native to Mexico, Central America, and the Andes, where it was a staple food of early Native American civilizations. Some species of amaranth have been cultivated since ancient times in many countries, as well as cereal and vegetable crops. The genus A. cruentus is native to Mexico and Guatemala and is currently cultivated on a small scale in mountain valleys of Mexico, Central, and South America. (Paredes and Hernandez, 1992). There are approximately 60-70 species, with 40 species native to the American continent and the rest of Australia, Africa, Asia, and Europe. (Luis et al., 2018); However, only 17 are edible. (López and Alonso, 2019).

Amaranth has leaves, stems, and flowers of very bright colors such as purple, orange, red, and gold. It is a non-grass dicotyledonous plant that produces grain-type seeds, so it has been called a pseudocereal, presenting High nutrient content with high protein quality and nutraceutical compounds. Adapts, responds to, and tolerates varying environmental conditions (Barba de la Rosa et al., 2009)not only to meet food security for growing populations, but also to provide more nutritious food, rich in good quality proteins and nutraceutical compounds. The amaranth (Amaranthus hypochondriacus. Its density can vary from 230 to 360x103 plants/ha depending on the species. Flowering plants can have a height of 43-80 cm, but at the time of harvest they reach 180 cm; Their seed yield can reach up to 4.1 t/ha, making it comparable to that of most cereals. The plants grow about two meters tall and mature to about 50 thousand seeds.(ParedesLópez & Hernández López, 1992)(Svirskis, 2003)

Nutritionally amaranth leaves and grain have an interesting chemical composition and superior nutritional value compared to other grains such as corn, beans, wheat, and soybeans. (Luis et al., 2018). The protein content of the grain is 13 to 18% compared to that of corn (12%), wheat (12% to 14%), and rice (7% to 10%); It contains almost twice the lysine of wheat protein, three times that of corn and is comparable to the lysine of milk; It has acceptable levels of sulfur amino acids, so amaranth is considered the most promising plant for economic development by the National Academy of Sciences of the United States (NAS) and by the Food and Agriculture

Organization of the United Nations. (Comisión de Agricultura, Ganadería, Pesca y Desarrollo rural, 2019)(Guaman, 2012); (ParedesLópez & Hernández López, 1992).

In Nicaragua, since 2007, different species of amaranth were incorporated for cultivation and production as a food alternative, through the Zero Hunger program financed by the Sixth Framework Program of the European Union, whose objective was based on generating an action strategy to reduce hunger in terms of Food and Nutrition Security as well as encouraging the development of the agro-industrial capacities of women producers in the communities La Bolsa and La Tejana of the department of Chinandega.

The objective of this research was to evaluate the development and behavior of the vegetative growth variables of amaranth cultivation under homogeneous cultivation conditions in the Department of Managua.

2. METHODOLOGY

The cultivation was developed in Managua during the months of June to September 2010, on land located in the Ricardo Morales Avilés University Campus (RURMA), located in the UTM geographical coordinates 1339564 North and 0579055 East.

The general climatic conditions of the test are those described by (Dirección General de Meteorología, 2008), the capital is characterized by having a topography inclined towards the coast of Lake Xolotlán or the northern band; the lat average annual temperature is 26.8 °C, oscillating between 28.8 °C (April) and 25.8 °C (December). The climate is that of Tropical Savannah (Aw) according to Köppen classification; There is a marked dry season of four to six months (December-April). The rainy season goes from May to October, with an average annual rainfall of 1230.3 mm, varying between 1059.5 (Asososca) and 1654 mm (Casa Colorada), presenting itself from Northeast to Southwest.

The size of the experimental unit was 50 m long by 10 m wide, with a total area of 500 m^2, it was organized into five furrows of 50 m long, with 50 cm between plants and between furrows, performing the following activities:

2.1. Preparation of the ground

With tools suitable for fieldwork, the land was cleaned of weeds, stones, and other debris that could disturb the emergence of the plants, later the land and furrows were levels, this activity was done 3 days before planting. The ground was moistened with the help of sprinklers for two days (morning and evening) to promote seed germination.

2.2. Sowing

The seeds of *Amaranthus cruentus* L. variety Amaranteca used in the trial were provided by Eng. Ajax Fonseca Trujillo (collaborator of the project "Amaranth, the food of the future"). With the help of a piece of stick, thin lines were made at the top of the furrows, then sown in the aforementioned lines and immediately covered the seeds with a thin layer of soil (approximately 0.5 cm), for this activity approximately 500 grams of seed were used.

Constant drip irrigation was applied for three days until the seedlings emerged, then night irrigation was carried out as needed.

2.3. Fertilization

It was carried out in two moments, during sowing, using the voleo technique on one side of the furrow, at a rate of two quintals per hectare and 30 days after the emergence of the plant at a rate of one quintal per hectare, immediately after weeding. A fertilizer based on nitrogen, phosphorus, and potassium was used (12-30-10).

2.4. Crop care and monitoring

There was an incidence of insects of the genera *Atta and Diabrótica*, they were controlled with chemical attractant and pyrethroid of broad spectrum respectively, in doses according to manufacturer and frequency of application according to presence; the species of the genus *Ctenosaura*, was controlled with trap cultures (beans); the birds were chased away with the noise of empty cans tied in mecate when moved by the wind.

2.5. Thinning, transplanting, and weeding

Once the seedlings emerged, thinning was carried out, leaving the plants more vigorous. The distance between plants was set at 50 cm, 21 days after germination transplantation was made from places with abundant germination to places where there was little or no emergence. Manual and second times were weeded, once during thinning and once four weeks after germination.

2.6. Variables

The study variables were the Plant Height (PA) in which six (06) plants were chosen from each furrow, the height from ground level to the terminal bud was recorded with a tape measure; several sheets (NH); leaf length (LH), measured from sixth to eighth leaf and stem diameter (DT) using a Vernier calibrator, was performed 20 cm from the base of the plant.

2.7. Measurement of vegetative growth variables

5 random and equidistant witnesses were determined, and unequivocally identified, tape measure, pencil, and notebook were used to make the measurements and annotations respectively, the data were collected weekly, starting on day 21 after planting, for nine consecutive weeks.

2.8. Statistical analysis

The experimental design used was the randomized complete design with four treatments AP, NH, LH, and DT. An analysis of variance (ANDEVA) was performed according to the proposed experimental design and Tukey's significance tests at 5% to identify the different interactions.

3. RESULTS AND DISCUSSION

The growth of the plants' treatments AP, NH, LH, and DT was evaluated, using the procedure of measurement of vegetative growth variables. The results are shown below.

Table 1

Total average maximum values, values per week, and the corresponding period

Variable	Total value	Maximum value per week	A week with maximum values
Floor height (cm)	255	52	7-8
Some sheets (pcs.)	109	21	5-6
Blade length (cm)	29.8	6.6	1-2
Stem diameter (cm)	4.2	0.86	1-2

There were differences in the total height of the plant, the average being 255 cm, the time at which the maximum value was reached was presented between weeks seven and eight with 21.4 cm; this result is higher than that reported by Olán et al. (2012) with the average height of 140 cm, by Zelaya (2015) with an average height of 146.8 cm during this same period, by García (2012) with an average height of 83 cm at a late date and by García et al. (2009) with an average height of 172 cm in the spring-summer crop of the year 2000.

Table 2 shows the results of the analysis of the variance between plant height and the number of leaves.

Table 2

Analysis of variance of plant height and number of leaves

Source of variation	Sum of squares	Degrees of freedom	Mean squares	Value of F	P value
Model	19093.37	25	763.73	7.48	0.0315
Floor height	19093.37	25	763.73	7.48	0.0315**
Error					
Coefficient of variation	408.50	4	102.13 12.91		
Total	19501.87	29			

Table 3 shows Tukey's test results (α = 0.05) for plant height and the number of leaves.

Table 3

Tukey's test (α = 0.05) for plant height and number of leaves

Floor height (cm)	The average number of sheets	N	Error	Rank
240	122	1	10.11	A
200	114	1	10.11	A
290	110	2	7.15	A
257	108	1	10.11	A
190	108	1	10.11	A
165	104	1	10.11	A
230	98	1	10.11	A
260	98	1	10.11	A
180	93	1	10.11	A
265	92	1	10.11	A
139	90	1	10.11	A
210	83	1	10.11	A
155	83	1	10.11	A
220	82	1	10.11	A
132	75	1	10.11	A
160	75	2	7.15	A
128	73	1	10.11	A
170	72	1	10.11	A
130	64	1	10.11	A
127	56	1	10.11	A
95	56	1	10.11	A
126	55	1	10.11	A
90	53	1	10.11	A
120	44	2	7.15	A
60	37	2	7.15	A
97	36	1	10.11	A

Averages with a common letter are not significantly different ($p > 0.05$)

The analysis of variance between plant height and the number of leaves shows that there is a significant effect between the height of the plant on the variable response number of leaves, which was evidenced by the value of the random probability of the event (p = 0.0315) that turned out to be lower than the critical level of comparison α = 0.05, which indicated that at least one of the height averages is different from the other. The degree of association between both variables was measured with Pearson's correlation coefficient, which turned out to be 0.84, which is close to 1, which showed a strong positive association.

Tukey's multiple comparison tests (p > 0.05) with a confidence limit of 95% show results with a maximum mean of 122 sheets for a maximum height of 240 cm (Table 3). Monsalvo and Oliver (2004) indicate that the variable plant height is associated with yield, at higher altitudes high yields have been recorded, however, according to Olán et al. (2012) Plants with a lot of height present problems of came and difficulty mechanized harvesting.

Tables 4 and 5 show the results of ANDEVA for the variables stem diameter and number of leaves.

The highest number of average leaves was 109, the upper count was obtained between weeks five and six with 21 units (Table 1). This result is higher than that reported by Zelaya (2015) with 36 leaves during this same period.

Table 4

Analysis of variance of stem diameter and number of leaves

Source of variation	Sum of squares	Degrees of freedom	Mean squares	Value of F	P value
Model	9463.98	6	1577.33	3.61	0.0113
Stem diameter	9463.98	6	1577.33	3.61	0.0113**
Error					
Coefficient of variation	10037.89	23	436.43 26.69		
Total	19501.87	29			

There is a significant effect of the stem diameter variable on the response variable Number of leaves, which is evidenced by a p = 0.0113 (random probability of the event), which turned out to be lower than the critical level of comparison, significance level α = 0.05. So it was shown that there is a cause-effect relationship between the stem diameter on the response variable No. of leaves.

Table 5

Tukey's test (α = 0.05) for stem diameter and number of leaves

Stem diameter (cm)	The average number of sheets	N	Error	Rank	
4.5	110.5	2	14.77	A	
5.0	90.5	2	14.77	A	B
4.0	89.67	12	6.03	A	B
3.5	77.0	2	14.77	A	B
3.0	65.44	9	6.96	A	B
2.5	53.0	1	20.89	A	B
2.0	37.0	2	14.77	A	B

Averages with a common letter are not significantly different ($p > 0.05$)

The Tukey multi-range test with an Alpha = 0.05, allowed us to demonstrate that there are statistical differences between the diameter of the stem and the No. of leaves of the plant. The plants with the highest vigor are those that obtained a stem diameter of 4.5 cm with 110 average leaves.

Tables 6 and 7 present the results of ANDEVA for the variables stem diameter and leaf length. The highest average blade length was 29.8 cm, and the highest measurement was obtained between weeks one and two at 6.6 cm (Table 1). This result is higher than that reported by Olán et al. (2012) with an average length of 17.4 cm, this author indicates that plants with leaf lengths close to or greater than 30 cm, can be used for forage yield; taking into account the recommendations of García et al. (2009), *Amaranhtus cruentus* would be an excellent choice in Nicaragua as a forage species, mainly because it has high amounts of protein calculated based on dry matter in the leaf (248 g / kg), in addition to its stability and good development.

Table 6

Analysis of variance of stem diameter and leaf length

Source of variation	Sum of squares	Degrees of freedom	Mean squares	Value of F	P value
Model	157.64	6	26.27	7.53	0.0001
Stem diameter	157.64	6	26.27	7.53	0.0001**
Error	80.22	23	3.49		
Coefficient of variation			6.93		
Total	237.87	29			

Significant differences were found between the variable Stem diameter, on the response variable Leaf length, which was evidenced by a p = 0.0001, (random probability of the event), which turned out to be lower than the critical level of comparison, significance level α = 0.05.

Table 7

Tukey's test (α = 0.05) for stem diameter and leaf length

Stem diameter (cm)	Average leaf length	N	Error	Rank		
5.0	32.0	2	1.32	A	B	
4.0	28.33	12	0.54	A	B	
4.5	28.0	2	1.32	A	B	
3.5	26.0	2	1.32		B	C
3.0	25.22	9	0.62		B	C
2.5	25.0	1	1.87			C
2.0	22.0	2	1.32			C

Averages with a common letter are not significantly different (p > 0.05)

The multiple range test performed by Tukey's test with an Alpha = 0.05, allowed to demonstrate that there are statistical differences between the Diameter of the stem concerning the dependent variable Length of the leaves, for which a maximum average value of 32.0 cm was obtained for the size of leaves in plants with a diameter of 5.0 cm.

The largest average stem diameter was 4.2 cm, the upper measurement was obtained between weeks one and two with 0.86 cm (Table 1). This result is higher than that reported by García (2012) with an average of 2.18 cm, by García et al. (2009) with an average of 3 cm, and by Olán et al. (2012) with an average diameter of 1.9 cm, according to the latter author, the stem diameter is a fundamental characteristic in amaranth, since it will directly influence the resistance to acame, the larger the diameter of the stem, so will be its resistance to overturning.

4. CONCLUSIONS

Amaranthus cruentus L. variety Amaranteca has viable phenotypic characteristics to be considered as a cultivation option in Nicaragua (under conditions similar to the trial).

The methodology applied in the crop, the season of the year, and the environmental conditions turned out to be adequate according to the results obtained in the research.

The good development of its vegetative parts (according to the results of the study), place it as an important forage source to take into account, for its nutritional qualities according to the authors cited.

There are significant effects among the variables under study: plant height and the number of leaves; stem diameter and the number of leaves; and stem diameter and leaf size.

The research to be done on amaranth is many, fertilization and fertilizer; pest and disease control; comparison of accessions in terms of yield and forage in various locations, climatic conditions, and soil types; Application of biotechnology to improve yield and reduce the effect of pests and diseases, planting dates, are some examples of them.

CITED WORK

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