Statistical interpretation of some growth parameters for *Asimina triloba* (L.) Dunal

Received for publication, April 10, 2014
Accepted, August 20, 2014

BEATRICE AGNETA SZILAGYI¹, DĂNĂILĂ-GUIDEA SILVANA²,
MONICA MARIAN³
University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Faculty of Horticulture,
3-5 Mănăștur Street, 400372, Cluj Napoca; Romania; e-mail:beatrisce16@yahoo.com
²University of Agronomical Sciences and Veterinary Medicine Bucharest, Faculty of Biotechnologies,
59 Mărăști Blvd, 011464, Bucharest; Romania; e-mail: silvana.danaila@yahoo.com
³Technical University of Cluj Napoca, CUNBM, 64 Victoriei Street, Baia Mare; Romania;
e-mail:nitella_ro@yahoo.com

Abstract

The present work aims to study the biological aspects pertaining to *A. triloba* (northern banana or pawpaw) with a view to integrating it into the urban green spaces of the Baia Mare depression. We evaluated the effects of experimental factors on the growth of the main stem of the plant and noticed the results of statistical analyses of the studied parameters. The article presents the results of statistical analyses. Regarding the growth dynamics in length of the *A. triloba* plant's three internodes, these differ: \( m_1 \text{ bm} = 0.986, m_2 \text{ bm} = 9.026, m_3 \text{ bm} = 34.413 \) for the Baia Mare set; \( m_2 \text{ Lupușel} = 8.203 \) and \( m_3 \text{ Lupușel} = 21.320 \) for the Lupușel lots. Statistical analyses revealed that the diameter of the northern banana plant's main stem grows when the two experimental factors of age and plant location are combined. Thus, the values of the variation index were \( F = 6.601 \) (\( p = 0.011^* \)) at the base diameter, \( F = 7.233 \) (\( p = 0.008 \)) at the middle diameter and \( F = 7.278 \) (\( p = 0.008^* \)) at the apex diameter, a characteristic that can be used in landscaping by imposing a symmetry on ornamentation.

Keywords: northern banana, growth parameters, urban area.

1. Introduction

*A. triloba* (L.) Dunal, is the only tree species of the *Annonaceae* family to be found in the temperate zones of North America (L.H. BAILEY [1]). This tree, which forms part of a family featuring exotic species, is little known in Europe and less so in Romania (D. FĂNUȚĂ-MIHĂILĂ & al. [2]). Although *Asimina* plants have existed in North America since Miocene times (fossils have been found in New Jersey), it was the American Indians who discovered the culinary and medicinal uses of this plant. The first studies regarding the fruit culture, taxonomy and selection of native *Asimina* populations dates to the end of the 19th century and the beginning of the 20th. Interest in widely promoting this species increased just after 1960 in the United States, Italy, China and Chile. In these countries, nurseries were set up and breeding and selection studies were performed in order to obtain new varieties (FL. STĂNICĂ et al. [3]).

The cultivated species that belong to *Annona sp.* cannot be adapted to the weather conditions prevailing in our country. They have persistent leaves and prefer climate conditions specific to subtropical and tropical regions. Unlike *Annona*, the *Asimina* genus includes 9 species adapted to temperate climates. Of these, the best known and appreciated is *A. triloba*. This is due to its adaptability to low temperatures (-25°C), to its potential as a quality fruit species and to its landscaping value (N. CEPOIU et al. [4]). In its area of origin...
A. triloba grows and develops in a bush shape and at maturity reaches a height of 5-10 m, with narrow leaves (DIRR [5]). The tree bark is uneven in surface, while the young branches are fuzzy (H. A. GLEASON & A. CRONQUIST [6]). In Romania, the northern banana grows in a similar fashion to what is observed in its native habitat. In our country, we see growth of little bushes of 3-7 m (FL. STÂNICĂ & N. CEPOIU [7]), or of trees (5-10 m high), with little fruits, conical or globular in shape.

From a landscape architecture point of view, A. triloba is valuable due to the shape and structure of the candelabra-style crown, and of the various shapes of the leaves (from obovate to oblong and lanceolate), which are 15-30 cm long. The leaves of the northern banana emanate a characteristic odor when rubbed (C.G.HUNTER [8]). In spring, the ornamental value of A. triloba flowers increases due to their placement on the twigs. They appear in groups of three or more per twig, with petals between 1.5 and 3.0 cm in diameter (D.R. LAYNE [9]). In autumn, the northern banana fruits attain maturity, reaching dimensions of 5-15 cm in length, with a seed ratio of 8-24%. The ornamental appearance of the Pawpaw tree recommends the northern banana plant as an "integral component of the aesthetic landscape" (LAYNE [9] and POMPER and LAYNE [10]). A. triloba is frequently found in landscaped arrangements in the United States [K. W. POMPER & al.[11], in: American Pomological Society 62 (3):89, 2008]. The Horticulture Department of the University of Florence, seeking to determine and evaluate the decorative possibilities of this plant, established the largest Italian plantation of A. triloba. Following measurements taken three times in a row, it was determined that northern banana trees grow 11.7 cm annually in height. The flowering period varies based on annual climate conditions (92-106 days), and 250 days are necessary for fruits to mature (E. BELLINI and D. MONTANARI [12], [13], E. BELLINI & al. [14], D.R. LAYNE [9], McLAUGHLIN [15], POMPER & al. [16], S.B.CRABTREE[17], G.M. DARROW[18]).

Rearranging the green spaces of Baia Mare will require landscape management. To this end, the experimental factors observed were plant age, the influence of initial seedling size on the general growth of A. triloba plants in terms of stem length, and the internode distances, as well as the main stem diameter at the base, medium and terminal level. The establishment of two experimental fields, at Baia Mare and Lăpușel, aimed at testing the growth and development of northern banana plants in different soil conditions in order to determine areas favorable for their growth.

2. Materials and methods

The planting material for this study came in the form of 295 northern banana seeds. These seeds, from which emerged the A. triloba plants used in the study, were entirely domestic in origin. The fruits that supplied the northern banana seeds were collected from mature individuals aged 10 years, planted in the spring of 2002 in the semi-rural area of Lăpușel Commune, 6 km away from Baia Mare. The fruit harvesting and seed gathering from the pawpaw plants were done in stages, based on maturity. It is considered that the fruits are effectively mature and are ready for harvesting when they come off the tree easily upon being nudged. In Lăpușel, this takes place at the end of September or the beginning of October.

Statistical data analysis was performed with the aid of the SPSS (Statistical Package for the Social Sciences) program, version 17. This is among the most effective and widely used statistics programs. The statistical apparatus for confirming the starting hypotheses are as follows:

- Single (ANOVA) and binary factor variance analysis. The F-indicator or variance relation that it generates indicates the existence of differences between the various analysis
groups, starting from certain selection criteria. The ANOVA single-factor grouping criteria in this case are as follows: groups of plants grown at Baia Mare and Lăpușel; plants aged 1, 2 and 3 years; plants growing from seedlings of differing sizes.

- A hierarchic regression analysis allowed us to evaluate the weight that one or more causal factors contribute to the variation in effect. In this case, the regression analysis was applied for growth prediction (according to the following criteria: length of the main stem, length of the internodes and dimensions of the main stem's diameter) based on the following predictors: plant age, location and initial seedling size.

Precision in interpreting results (regarding the influence of experimental factors and the calculation of growth predictions for *Asimina triloba* plants studied) was achieved by dividing the planted material into a number of categories. The selection criterion for northern banana plants, which represents the object of study for the two experimental groups, was the plants' dimensions at the time when experiment groups were set up. To this end, the stem lengths and diameters were measured for the two groups of pawpaw plants set up in Baia Mare and Lăpușel. Each of the two experimental groups (Baia Mare, Lăpușel) was further divided into sub-groups of five individuals, based on stem dimensions:

- Baia Mare experimental group:  
  - sub-group I (small) (7.3 – 7.9 cm);  
  - sub-group II (medium) (8.1 – 8.3 cm);  
  - sub-group III (large) (8.8 – 9.7 cm).

- Lăpușel experimental group:  
  - sub-group I (small) (7.0 – 7.3 cm);  
  - sub-group II (medium) (7.5 – 7.7 cm);  
  - sub-group III (large) (7.8 – 8.0 cm).

In keeping with the correct measurements taken in the field, the stem of each plant was divided into three proportional segments starting at the soil surface and named as follows: first segment - basal; second segment - middle; third segment - apex. Starting with this selection method, we observed that we could take measurements of the main stem diameter as well as the plants’ internode distances with heightened precision.

The plant stem diameters were measured with digital calipers at the following distances from the soil surface:

- two centimeters from the basal diameter;  
- five centimeters from the middle diameter;  
- eight centimeters from the apex diameter.

The same considerations taken into account for measuring diameters were applied to measuring and determining the number of main-stem internodes. This is a factor of paramount importance when it comes to determining the decorative potential of *A. triloba* at different stages of development.

### 3. Results and discussion

Following observations carried out on northern banana plants during the first, second and third years on the two experimental fields, alongside the experimental factors "age" and "plant location", it was determined that a third factor influences lengthwise plant growth: initial plant size. This factor has a direct and positive impact on plant stem growth.

Given that when planting occurred in the two locations, there was a wide variety in stem length, the specimens were grouped into three categories: small, medium and large plants. The small plants were those with a stem length of 7.0 to 7.5 cm in the first year, the medium plants between 7.6 and 8.3 cm, while the large ones between 8.4 and 9.6 cm. Our goal was to determine to what extent the initial height of the plants influences main stem growth in the first three years of vegetation.
Combining the two variance factors of plant age (two and three years) and initial plant size (small, medium and large) forms a base for differentiated measurement of the main stem length. Table 1 summarizes the results.

Table 1. Variation of Asimina triloba (L.) Dunal main stem growth in relation to initial size and plant age

<table>
<thead>
<tr>
<th>Plant age, years</th>
<th>Initial plant size</th>
<th>Stem length</th>
<th>Number of specimens</th>
<th>F category</th>
<th>F age</th>
<th>F category *age</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Small plant</td>
<td>8.0950</td>
<td>5</td>
<td>F = 33.893</td>
<td>p = 0.000**</td>
<td>F = 209.585</td>
</tr>
<tr>
<td></td>
<td>Medium plant</td>
<td>8.6950</td>
<td>5</td>
<td></td>
<td></td>
<td>p = 0.000**</td>
</tr>
<tr>
<td></td>
<td>Large plant</td>
<td>9.3250</td>
<td>5</td>
<td></td>
<td></td>
<td>p = 0.000**</td>
</tr>
<tr>
<td>3</td>
<td>Small plant</td>
<td>16.3150</td>
<td>5</td>
<td></td>
<td></td>
<td>F = 27.981</td>
</tr>
<tr>
<td></td>
<td>Medium plant</td>
<td>25.7600</td>
<td>5</td>
<td></td>
<td></td>
<td>p = 0.000**</td>
</tr>
<tr>
<td></td>
<td>Large plant</td>
<td>41.5250</td>
<td>5</td>
<td></td>
<td></td>
<td>p = 0.000**</td>
</tr>
</tbody>
</table>

** significant to a p-value of 0.01
* significant to a p-value of 0.05

As table 1 shows, average values for stem lengths from years 2 and 3 differ significantly, and the plants’ growth cycle likewise differs based on the starting point (stem length in the first year). Plants that were initially small tended to double their stem length between the second and third year (variance of m2 small = 8.095 to m3 small = 16.3150), plants that were initially medium in size tended to triple their length between the second and third year (from m2 medium = 8.0695 to m3 medium = 25.7600), while initially large plants quadrupled their stem length between the second and third year (evolution from m2 large= 9.3250 to m3 large = 41.5250). An analysis of the F-values and the p-values leads to the following conclusions.

Regarding main stem length as it relates to plant age:

For the three subgroups of pawpaw plants, it was observed that the main stem length compared with initial plant size differs very significantly among themselves (F = 209.585). This fact allows us to assert with confidence (margin of error 0, since p = 0.000*) that the length of the main stem increases substantially each year and that plant age is highly significant as a variance factor for lengthwise growth of the main stem.

If we analyze the average stem length and compare it to the initial size of plants, we observe that the three subgroups (small, medium and large plants) display statistically significant differences (F = 33.893) with a margin of error of 0, since (p = 0.000*). Variation in main stem length thus depends significantly on initial plant size.

If we combine the two experimental factors (category*age), we notice that the value of the F-index attached to the main stem length recorded for A. triloba plants is F = 27.981, which indicates significant differences between the subgroups, a statement confirmed by the margin of error 0 (p = 0.000*). In other words, we can affirm that the two criteria (category*age) taken as a whole are basic criteria for lengthwise growth of the main stems of northern banana plants.

The F-index of variance for plant age influences, to a great degree, growth in the stem F = 209.585.

In order to quantify the weight that the two experimental factors (initial plant size, initial size*age) contribute to the growth in the main stem of plants, we applied a regression analysis. The results obtained are displayed in table 2 and show the value of the r correlation coefficient as well as of the R² determining coefficient together with the p-values for these data.

A multiple regression analysis allows us to determine and to quantify the weight that the two experimental factors, initial plant size and age contribute to the growth of the main stem in northern banana plants. To this end, we used two prediction models: the first calculates the degree to which initial plant size affects growth in the main stem of the plants.
analyzed. The second prediction model allows us to analyze to what degree the two experimental factors (initial plant size; initial plant size*age) taken as a whole affect growth in the main stem of the A. triloba studied plants.

Table 2. Prediction of Asimina triloba (L.) Dunal main stem length based on initial plant size and age

<table>
<thead>
<tr>
<th>Prediction model</th>
<th>R²</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the plant's stem</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial plant size</td>
<td>0.141</td>
<td>0.386</td>
<td>0.000**</td>
</tr>
<tr>
<td>Model 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial plant size*age</td>
<td>0.611</td>
<td>0.386</td>
<td>0.000**</td>
</tr>
</tbody>
</table>

Predictors: Model 1 - initial plant size ** significant to a p-value of 0.01
Model 2 - initial plant size*age * significant to a p-value of 0.05
Dependent variable: stem length

For the first prediction model, in which we analyze the influence of the initial plant size on the growth of the main stem length, table 2 presents the following findings:
- the values of the correlation coefficient r are significant and positive: r_{model 1} = 0.386; p = 0.000; this implies that the length of the plant's main stem increases in parallel with the growth in initial size of the A. triloba plants;
- analysis of the R² determining coefficient shows that the initial plant size contributes 14.1% of the growth in the main stem length of northern banana plants (R²_{model 1} = 0.141).

For the second prediction model, in which initial size*age are taken together as growth factors for the main stem length, the following were observed:
- the values of the correlation coefficient r are significant and positive: r_{model 2} = 0.386; p = 0.000; which means that the plant's main stem length grows in proportion to the initial size*plant age of the values of A. triloba plants;
- analysis of the R² determining coefficient shows that the initial plant size*age supplies 61.1% of the main stem growth in pawpaw plants (R²_{model 2} = 0.611).

Comparing the two prediction models (Model 1: initial plant size; Model 2: initial plant size*age), we observed that the second prediction model exercises the greater influence. The first model affects growth to a much smaller degree. Adding the experimental factor "plant age" to the experimental factor "initial plant size" increases the variation in the plants' main stem length by a further 47% (R²_{model 2} = 61.1% versus R²_{model 1} = 14.1%). These results can be summed up by stating that 47% of stem growth is due to age and initial size of the plant.

Table 3 synthesizes the measured values of internodes one, two and three of the main stem of the A. triloba plants. Analyzing the data included in table 3, reveals that the growth dynamics in terms of length of the three internodes of northern banana plants differ:
- the greatest variation is observed in internode two, where growth from one part of the year to the next, and from one site to another, differs tremendously (from m₁ bm = 0.986, m₂ bm = 9.026, m₃ bm = 34.413; for the Lăpușel lots, also for the length of internode two, the values are m₂ lăpușel = 8.203 and m₃ lăpușel = 21.320);
- the dynamics of internodes one and three appear to be less dramatic (for internode one, m₁ bm = 1.023 and for internode three, m₁ bm = 0.788; for internode 1, m₂ bm = 2.00 and internode 3 m₂ bm = 1.300; internode 1 m₂ lăpușel = 1.825 and internode 3 m₂ lăpușel = 1.143).

Therefore, we highlight that in the table 3 we observe that in the first two years, there existed a proportional growth in length for internodes 1 (one), 2 (two), 3 (three), while noticing impressive growth in the values associated with the third year (the lengths almost tripling at Lăpușel and quadrupling at Baia Mare), both in Lăpușel and in Baia Mare, especially for the first two internodes. For internode three, the third year causes a mere
doubling of its length. This could be due to the fact that internode three is still in a process of transition and that the plant has yet to reach full maturity.

Starting with these raw data, we applied a variance analysis by choosing experimental factors that have a statistically significant influence on lengthwise growth of the plant internodes. Table 3 summarizes these tendencies in the form of F-values.

Table 3. Variation of main stem internode length based on age and plant location in *Asimina triloba* (L.) Dunal

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Location</th>
<th>Average length of internode 1 (mm)</th>
<th>Average length of internode 2 (mm)</th>
<th>Average length of internode 3 (mm)</th>
<th>Number of plants tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Baia Mare</td>
<td>1.023</td>
<td>0.986</td>
<td>0.788</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Baia Mare</td>
<td>2.000</td>
<td>9.026</td>
<td>1.300</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Lăpușel</td>
<td>1.825</td>
<td>8.203</td>
<td>1.143</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>Baia Mare</td>
<td>8.746</td>
<td>34.413</td>
<td>2.441</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Lăpușel</td>
<td>6.332</td>
<td>21.320</td>
<td>2.153</td>
<td>15</td>
</tr>
</tbody>
</table>

A multiple regression analysis allowed us to learn and to quantify the weight that each of the experimental prediction models (age, age*location) contributes to the lengthwise growth of the internodes in *A. triloba* plants. To this end, we used two prediction models: the first calculates the degree to which plant age affects modifications in the internode length. The second allows us to analyze to what degree the two experimental factors (age*location) taken as a whole affect growth in the internode intervals measured in the study (table 4).

Table 4. Growth prediction for internode lengths in the main stem of *Asimina triloba* (L.) Dunal based on plant age and location

<table>
<thead>
<tr>
<th>Internode</th>
<th>Prediction model</th>
<th>R²</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internode 1</td>
<td>Model 1 Age 0.442</td>
<td>0.668</td>
<td>0.000**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Model 2 Age 0.455</td>
<td>0.622</td>
<td>0.000**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>*location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internode 2</td>
<td>Model 1 Age 0.553</td>
<td>0.740</td>
<td>0.000**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Model 2 Age 0.620</td>
<td>0.836</td>
<td>0.000**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>*location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internode 3</td>
<td>Model 1 Age 0.172</td>
<td>0.426</td>
<td>0.000**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Model 2 Age 0.182</td>
<td>0.503</td>
<td>0.000**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>*location</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Predictors: Model 1- age **significant to a p-value of 0.01**
Model 2 - age and location *significant to a p-value of 0.05*
Dependent variable: length of internodes 1, 2, 3

For **the first prediction model**, in which we analyze the influence of the plant's age on growth in the internode length, table 4 presents the following values:

- the value of the r coefficient of correlation for both nodes is significant (r internode 1 model 1 = 0.668; p = 0.000; r internode 2 model 1 = 0.740; p = 0.000 and r internode 3 model 1 = 0.426), which means that internode lengths in the *A. triloba* plants grow proportionally with age;
- analysis of the R² determining coefficient shows the following tendencies: plant age contributes a weight of 44.2 % to the growth in length of internode 1 (one) of the main stem in northern banana plants (R² internode 1 model 1 = 0.442), a weight of 55.3 % to the growth in length of internode 2 (two) of the main stem in pawpaw plants (R² internode 2 model 1 = 0.553), and just 17.2 % for internode 3 (three) R² internode 3 model 1 = 0.172).
For the second prediction model, in which plant age and location are taken together as growth factors in internode length, we observed that:

- the values of the correlation coefficients for the two models taken as a whole are significant and positive ($r_{\text{Internode 1 model 2}} = 0.622$; $r_{\text{Internode 2 model 2}} = 0.836$; $r_{\text{Internode 3 model 2}} = 0.503$); the greatest correlation coefficient was recorded for internode 2 (two);
- the determining coefficients of the two models are themselves significant; the proportion that each of the two nodes contributes to growth in internode length is as follows: 45.5 % for internode 1(one) ($R^2_{\text{Internode 1 model 2}} = 0.455$), 62.2 % for internode 2 (two) ($R^2_{\text{Internode 2 model 2}} = 0.622$), and 18.2 % for internode 3 (three) ($R^2_{\text{Internode 3 model 2}} = 0.182$).

Comparing the two prediction models (M1 and M2), we observe that plant age has the greatest influence, while location influences length only to a secondary degree, in a much smaller proportion. For internode 1(one), adding the location factor increases this variation a further 1.3 % (44.2 % versus 45.5 %), for internode 2 (two), location adds 6.7 % to growth as opposed to age alone (62 % instead of 55.3 %) and 1 % for the length of internode 3 (three), (18.2 % versus 17.2 %).

We observed that the two experimental factors taken as a whole boost growth in $A. \text{triloba}$ plants on the interval of internode 2 (two) by the greatest amount.

Based on the values recorded in table 5, we found that growth dynamics in the main stem diameters differed on the three levels.

**Table 5.** Relationship between base, median and apex diameter of the main stem in $A. \text{triloba}$ (L.) Dunal plants based on plant location and age

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Location</th>
<th>Average base diameter of stem (mm)</th>
<th>Average middle-level diameter of stem (mm)</th>
<th>Average apex diameter of stem (mm)</th>
<th>Number of plants tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Baia Mare</td>
<td>2.830</td>
<td>1.852</td>
<td>1.296</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Baia Mare</td>
<td>4.243</td>
<td>2.646</td>
<td>1.706</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Lăpușel</td>
<td>4.228</td>
<td>2.723</td>
<td>1.740</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>Baia Mare</td>
<td>5.780</td>
<td>4.391</td>
<td>3.123</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Lăpușel</td>
<td>4.630</td>
<td>3.118</td>
<td>2.143</td>
<td>15</td>
</tr>
</tbody>
</table>

For the base diameter of the stem, we observed variations, on the one hand from one level to the next, and on the other from one location to another (from $m_{1 \text{bm}} = 2.830$, to $m_{2 \text{bm}} = 4.243$, respectively $m_{3 \text{bm}} = 5.780$ - where $m_1$, $m_2$ and $m_3$ refer to the variations for the three years. For the Lăpușel lots, the values also for the base region are: $m_{2 \text{lăpușel}} = 4.228$, respectively $m_{3 \text{lăpușel}} = 4.630$). Analyzing the data, we observed that across three years of growth, the greatest variations were recorded between the values of the Baia Mare plants' base diameters. In Lăpușel, growth in thickness between years 2 (two) and 3 (three) did not reach the values obtained for the plants in Baia Mare.

For the middle-level diameter, growth was also influenced by plant age, with proportionality being kept as regards the base level, but to a lesser degree ($m_{1 \text{bm}} = 1.852$, $m_{2 \text{bm}} = 2.646$, $m_{3 \text{bm}} = 4.391$; at Lăpușel $m_{2 \text{lăpușel}} = 2.723$ and $m_{3 \text{lăpușel}} = 3.118$). In similar fashion, differences appear between the size of this diameter in Lăpușel plants, where the values are smaller than those found at Baia Mare.

For the apex diameter, observations made at the other diameters remain valid, only that the starting values are much smaller ($m_{1 \text{bm}} = 1.296$, $m_{2 \text{bm}} = 1.706$, $m_{3 \text{bm}} = 3.143$; at Lăpușel, $m_{2 \text{lăpușel}} = 1.740$, $m_{3 \text{lăpușel}} = 2.143$).

Synthesizing the entirety of the data, we found that there is a proportional continuity of diameter growth of the whole stem, a fact that can be useful in landscape architecture in terms of planning ornamental symmetry.
In order to express the contribution of the experimental factors "age" and "location" as a percentage value, to the growth in size of the main stem diameter of the *A. triloba* plants, we calculated the F-variance relations and the p-values, reaching the following conclusions (table 6):

Table 6. Dispersion indices for base, mid-level and apex diameters of the main stem in *Asimina triloba* (L.) Dunal plants based on measurement year and plant location

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Location</th>
<th>F-distribution of the base stem diameter</th>
<th>F-distribution of the mid-level stem diameter</th>
<th>F-distribution of the apex stem diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Baia Mare</td>
<td>F age = 16.220</td>
<td>F age = 26.111</td>
<td>F age = 23.269</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p = 0.000**</td>
<td>p = 0.000**</td>
<td>p = 0.000**</td>
</tr>
<tr>
<td>2</td>
<td>Baia Mare Lăpușel</td>
<td>F location = 6.002</td>
<td>F location = 5.569</td>
<td>F location = 6.352</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p = 0.015*</td>
<td>p = 0.020*</td>
<td>p = 0.013*</td>
</tr>
<tr>
<td>3</td>
<td>Baia Mare Lăpușel</td>
<td>F age*location = 6.601</td>
<td>F age*location = 7.233</td>
<td>F age*location = 7.278</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p = 0.011*</td>
<td>p = 0.008*</td>
<td>p = 0.008*</td>
</tr>
</tbody>
</table>

**Significant to a p-value of 0.01
*Significant to a p-value of 0.05

For the *base diameter*, the observations recorded are as follows:
- for the three subgroups of pawpaw plants ages one, two and three years, we observed that the diameter sizes differed significantly among themselves (F = 16.220). This allows us to state with certainty (margin of error 0, size p = 0.000*) that the base diameter size grows substantially each year; that plant age as a variance factor is significant for growth in the stem diameter of *A. triloba* plants at the base;
- analyzing the average diameter of the main stem at the base level in terms of location, we find that the two subgroups (Baia Mare and Lăpușel) present statistically significant differences among themselves for the two subgroups analyzed (F = 6.002), margin of error (p = 0.015*). This means that variance in the main stem diameter at the base level depends significantly on plant location;
- if we combine the two experimental factors (plant age and location), we find that the F-index value attached to the main stem diameter at the base level, in the case of the five subgroups it generates, is F = 6.601 and that significant differences among the subgroups are indicated (p = 0.011*).

The finding we state after analyzing table 6 is that the two criteria (age and location) taken as a whole are relevant criteria for the diameter growth of the main stem of pawpaw plants at the base level.

For the size of the *mid-level diameter*, the conclusions are as follows:
- comparing average values for the diameters of the three subgroups of northern banana plants aged one, two and three years, we find that these diameters differ significantly among themselves (F = 26.111, p = 0.000**). Thus, main stem diameters at the mid-level (as at the base level) grow substantially every year, so that plant age as a variance factor is significant for diameter growth of *A. triloba* plants at the mid-level;
- if we analyze stem diameter size at the mid-level in terms of location, we observe that the two subgroups (Baia Mare and Lăpușel locations) differ significantly between themselves (F = 5.569) and the margin of error that we allow for this statement is p = 0.020*.

Combining the two variance factors of plant location and age shows that the value of the F-index F = 7.233 is significant for the five subgroups analyzed (p = 0.008*).

For the size of the *apex diameter*, the influences recorded are as follows:
- for the three subgroups of *A. triloba* plants aged one, two and three years, we observe that the diameter values differ significantly among themselves (F = 23.269, p = 0.000**). Thus,
values for main stem plant diameters at the apex level increase substantially each year. Plant age as a variance factor is significant for growth in stem diameter in northern banana plants at the apex level;

- if we analyze the average diameters of main stems at the apex level, based on the location factor, we observe that the two subgroups Baia Mare and Lăpușel present a statistically significant difference among themselves $F = 6.352$, margin of error $p = 0.013^*$. This means that variance in diameter at the apex level depends significantly on plant location;

- if we combine the two experimental factors (plant age and location), we find that the value of the F-index for the length of internode three, in the case of the five subgroups analyzed, is $F = 7.278$ and this indicates significant differences among the subgroups ($p = 0.008^*$).

We can state with certainty that the two criteria (age and location) are relevant for main stem diameter growth in *Asimina triloba* at the apex level.

In order to determine the size of main stem diameter growth in pawpaw, based on the two experimental factors (age, age*location), we performed a multiple regression analysis in table 7.

To this end, we used two prediction models: the first calculates the degree to which plant age contributes to the modification of the three diameters (base, middle and apex) on the main stem. The second prediction model allows us to analyze to what degree the two experiment factors (age*location) taken as a whole contribute to growth in the main stem diameters of the northern banana plants studied (table 7).

For the first prediction model, in which we analyze the influence of plant age on diameter growth in the three points measured (base, middle and apex) table 7 presents the following values:

- values of the $r$ correlation coefficient for both models are significant ($r_{\text{diameter at base model } 1} = 0.369, \ p = 0.000$; $r_{\text{diameter at middle model } 1} = 0.484, \ p = 0.000$ and $r_{\text{diameter at apex model } 1} = 0.442, \ p = 0.000$), which means that the size of the main stem diameter in the northern banana grows proportionally with age;

- analyzing the $R^2$ correlation coefficient shows the following tendencies: plant age contributes a weight of 13 % to base diameter growth in the main stem of the *A. triloba* plants ($R^2_{\text{diameter at base model } 1} = 0.130$), with a weight of 22.9 % to mid-level diameter growth in the main stem of the pawpaw plants ($R^2_{\text{diameter at middle model } 1} = 0.229$) and with 19 % in the case of the apex diameter growth in the main stem of the northern banana plants ($R^2_{\text{diameter at apex model } 1} = 0.190$).

Table 7. Growth prediction of main stem diameter as a function of age and plant location in *Asimina triloba* (L.) Dunal

<table>
<thead>
<tr>
<th>Main stem diameter</th>
<th>Prediction model</th>
<th>$R^2$</th>
<th>$r$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main stem diameter at base</td>
<td>Model 1 Age</td>
<td>0.130</td>
<td>0.369</td>
<td>0.000**</td>
</tr>
<tr>
<td></td>
<td>Model 2 Age *location</td>
<td>0.147</td>
<td>0.431</td>
<td>0.000**</td>
</tr>
<tr>
<td>Main stem diameter in the middle</td>
<td>Model 1 Age</td>
<td>0.229</td>
<td>0.484</td>
<td>0.000**</td>
</tr>
<tr>
<td></td>
<td>Model 2 Age *location</td>
<td>0.251</td>
<td>0.538</td>
<td>0.000**</td>
</tr>
<tr>
<td>Main stem diameter at apex</td>
<td>Model 1 Age</td>
<td>0.190</td>
<td>0.442</td>
<td>0.000**</td>
</tr>
<tr>
<td></td>
<td>Model 2 Age *location</td>
<td>0.235</td>
<td>0.510</td>
<td>0.000**</td>
</tr>
</tbody>
</table>
Predictors: Model 1 - age **significant to a p-value of 0.01
Model 2 - age, location *significant to a p-value of 0.05
Dependent variable: stem diameter at apex, base and middle

For the second prediction model, in which plant age and location are taken together as growth factors for the main stem diameter in the *A. triloba* plants, the following are observed:

- the values of the correlation coefficients for the two models taken as a whole are significant and positive (r diameter at base model 2 = 0.431, p = 0.000; r diameter at middle model 2 = 0.538, p = 0.000 and r diameter at apex model 2 = 0.510, p = 0.000).

The coefficients of determination of the two models analyzed together (age, age*location) are also significant, the proportion that each of the two models contributes to growth of the main stem diameter of the *A. triloba* is as follows: 14.7 % for the base diameter ($R^2_{diameter at base model 2} = 0.147$), 25.7 % for internode 2 (two) ($R^2_{diameter at middle model 2} = 0.251$) and 23.5 % for internode 3 (three) ($R^2_{diameter at apex model 2} = 0.235$).

Given that a proportional relation is preserved between the values of the coefficients of determination ($R^2$), as well as between the coefficients of correlation (r), with positive p-values (p = 0.000), table 7 shows us the fact that the experimental factors of age and plant location are decisive elements in the growth and diametrical development of the three levels measured in the main stem of the northern banana plants.

### 4. Conclusions

In conclusion, we can state that the process of growth and development in the main stems of the *A. triloba* plants analyzed experiences a spectacular increase in the third year for all three plant categories (small, medium and large). We observed the most growth in large plants. This statement is based on the value of the F-factor for plant age, $F = 209.585$, while 47 % of stem growth is due to the plant's initial age and size.

The northern banana plants beautifies through its shape and the size of its main stem starting in the third year of growth. The coefficients of determination for the two models analyzed together (age and age*location) are significant: the proportions that each of the two models contributes to growth in the main stem diameter of the *A. triloba* plants are as follows: 14.7 % for the base diameter ($R^2_{diameter at base model 2} = 0.147$), 25.1 % for internode 2 (two) ($R^2_{diameter at middle model 2} = 0.251$) and 23.5 % for internode 3 (three) ($R^2_{diameter at apex model 2} = 0.235$).

We recommend using pawpaw plants with variable initial sizes for planting in green spaces. Their landscape architecture value will also be influenced in the first three years by the initial plant size, but it is possible that with growth, this difference will fade away and the smaller plants catch up in subsequent years.

In designing green spaces for the Baia Mare urban depression, formed from bushes decorative because of their leaves and horizontal-growing conifers, placing the northern banana plants among the already extant plants will cause it to be noticed due to its shape and the size of its straight-growing trunk.

From a landscape architecture viewpoint, this observation encourages us to use *A. triloba* plants at least two years old in green spaces, since it is at that point that the plant acquires a decorative trunk.

Environmental conditions in Baia Mare and Lăpușel (soil composition, temperature variation, wind speed, quantity of precipitation, atmospheric humidity, etc.) directly influence the growth in diameter of pawpaw plants at the base, middle and apex levels.
Taken as a whole, the landscape architecture conclusion that results is that once *A. triloba* plants grow in age, the thicknesses of the three diameters in their main stems also grow, so that the plants' main stems, as they develop, take on a tree-like aspect and thus can be placed alongside smaller ornamental plants.

**References**