MORPHOLOGICAL AND PHYSIOLOGICAL FEATURES OF THE SPECIES *Asimina triloba* (L.) DUNAL, INTRODUCED AS AN ORNAMENTAL PLANT IN BAIA MARE (MARAMUREŞ COUNTY, ROMANIA)

Beatrice SZILAGYI[*], Monica MARIAN[**]

[*] *USAMV Cluj –Napoca, IOSUD, 3-5 Manastur, Cluj Napoca, Romania*
[**] *North University of Baia Mare, Faculty of Science, Department of Chemistry-Biology, Baia Mare, Romania*
Corresponding author: Monica Marian, North University of Baia Mare, Faculty of Science, Department of Chemistry-Biology, 76 Victoriei., 430122 Baia-Mare, Romania, tel.: 0040262430122, fax: 0040262276153, e-mail: monica.marian@bioresearch.ro

Abstract. Tree species *Asimina triloba* (L.) Dunal, is native to North America. In the area of origin is cultivated, both as food species because the edible fruit, and as ornamental species. Ornamental value derives both from decorative flowers, that open in early spring, and because habitus species. The species is demanding from slightly acidic soils (pH 5.5 to 7.0) and well drained. Seedlings are susceptible to heatstroke and need areas of the sun, but since the second year, vegetate well in bright light conditions [27]. Optimum climate is temperate to subtropical one. The species exhibits unique quality traits for a temperate fruit that are similar to other fruit in the Annonaceae family, including cherimoya (*Annona cherimola* Mill.), sugar apple or sweetsop, (*A. squamosa* L.), soursop (*A. muricata* L.), custard apple (*A. reticulata* L.), and atemoya (*A. squamosa* X *A. cherimola*), all of which are tropical [2].

This study follows the behavior of the species, in particular conditions of the Baia Mare and its surroundings. In this area a few individuals were introduced, in order to diversigy the range of species of ornamental plants. In Baia Mare, topoclimate is specifically depression, sheltered by mountains, more atenuated as temperature and winds, than in surrounding areas. As a result of climatic conditions, chestnut *Castanea sativa*, grows in good conditions in Baia Mare. Instead, the area is heavily polluted, especially at ground level. Pollution by heavy metals is a historical being generated by the mining industry.

The introduction and use of a new plant species into a new area involves: 1. easy to obtain seed; 2.- maintaining the crown shape habitus and and leaf shape and size, respectively; 3 – determination of optimal physiological parameters. Therefore have been performed, the following experimental determinations: 1. - germination of seed obtained in the particular conditions of the Baia Mare; 2. - some morphomtric characteristics of leaves, in the juveniles of the 1-2 years; 3. – the dynamic of photosynthesis intensity in these plants, during the day, during summer/autumn months.

The study results are promising for acclimatization of the species *Asimina triloba* (L.) Dunal in particular conditions of Baia Mare. Morphological and physiological parametres tested are maintaned at similar to those of native habitat, described in the literature.

Keywords: *Asimina triloba*, physiological features, photosynthesis intensity, ornamental value.

INTRODUCTION

Pawpaw is a native American fruit tree that has potential for use as a new fruit crop or in landscapes [7, 16, 24]. Besides the potential due to fruit edible fruit, the taste of banana, mango and pineapple, can be recovered and ornamental species, and medicinal [7, 16, 23, 24].

Pawpaw is being developed as a specialty fruit crop and is a source for novel secondary products [2, 12, 16]. Pawpaw promise natural compounds (annonaceous acetogenins) in the leaf, bark, and twig tissues that possess insecticidal and anticancer properties [20, 25]. Native pawpaw patches can be found in mesic hardwood forests growing in large patches as understory trees and can be found in 26 states in the eastern United States, ranging from northern Florida to southern Ontario, Canada, and as far west as eastern Nebraska [3, 4, 15, 28]. As a species to climate preferences, tropical and temperate to one, there is potential to be introduced, acclimatized and valued in the north of Romania, housed and milder microclimates, such as the Baia Mare.

MATERIALS AND METHODS

a. Testing of germination capacity

Germination capacity of the species, was tested on seeds from the production of Lăpuşel. In the village Lăpuşel located near Baia Mare (less than 10 km), one *Asimina* individual, 15 years age, grow and produce fruit and seeds. This individual produces each year, fruit and fertile seeds, in outdoor conditions.

Fruit harvested was carried out in September – October 2008, in stages, during to their maturation. They contain usually 2 seeds. The seeds were subjected to the process process of stratification (vernalisation) al 2-4 ^{0}C, 140 days, in different types of substrate:

1. gravel, sand, soil litter forestry and vegetal sponge
2. gravel, peat and *Spagnum* moss.
3. medical gauze and sand.

In each type of substrate were used 30 seeds. After this process, seeds from different types of stratification, were subject of germination, in two temperature ranges: 20-22^{0}C, 28-30^{0}C, respectively.

It was calculated the germination capacity in each of these experimental variations.

b. Measuring morphological parameters of the leaves

Seedlings obtained by germination, were the subjects of work in the subsequent test. Some of them were grown in the open, unprotected space (in the garden), and another part has been raised in indoor conditions. For both groups, each consisting of 10 individuals, morphometric measurements were performed. The plants grown in outdoor conditions, were associated in combination with other ornamental species commonly used in Baia Mare. Five experimental variants were tested, representing as many combinations, to assess the best one, for the inclusion of the reference species *Asimina triloba* Dunal.

V1 – *Cotoneaster dammeri, Euonymus fortunei, Berberis thunbergii, Asimina triloba.*

V2 –*Mahonia aquifolium, Euonymus fortunei, Hibiscus syriacus, Asimina triloba.*

V3 – *Symphoricarpos albus, Forsythia x intermedia, Asimina triloba.*

V4 - *Rhus th., Viburnum opulus, Elaeagnus angustifolia, Paulownia tomentosa, Salix matsudana, Asimina triloba.*

V5 – *Castanea sativa, Quercus robur, Asimina triloba.*

Measurements were performed on foliar limbus, at the leaves located at the base, mid, repsectively from the top of the stem. Length and width were measured at the foliat limbus. Basal leaves belong to the first three basal stem nodes, and those at the top, are attached to the last three caulinar nodes. The intermediary arranged are treated as median leaves. Measurements were made monthly during the vegetation season, from May to September, in 2011.

c. Measuring the intensity of photosynthesis

As an expression of physiological adaptability of species under the tested area, measurement of the intensity of photosynthesis were carried out. He has performed with the device EARS miniPPM. The PPM measures the quantum yield of photosynthesis. In other wors: the efficienty of a plant to convert light and CO_2 into biomass. The measurements were made every last week of the each month, from Juley to September 2011. In parallel, measurements were performed both in plants grown indoor, as well as those grown in open spece.

Measurement were performed 3 times during the day: morning, noon, afternoon, at leaves basal, middle and terminal. Interpretation of results, taken into account, the temperature and light conditions of the moments in wich measurement were made.

e. Statistical

Data obtained from measurements were statistically processed through Past program. Both singel ANOVA and bifactorial were processed. In adidition, other statistical processing were perfomed as: cluster analysis based on Euclidian equation, analysis on the main factors etc.

RESULTS

a. Testing of germination capacity

The results with germination capacity of the seeds are presented in Table 1.

b. Measuring morphological parameters of the leaves

Leaves of the *Asimina triloba* (L) Dunal plants, grown in Baia Mare, aged 1-2 years, recorded the following dimensions: the lenght between 5.82 and 13.96 cm and the width between 2.68 and 4.84 cm. By comparison, measurements made in the research center in Kentucky, on plants grown in the area of origin of the species, have following vales: length – between 7 and 15 cm and width between 5 and 8 cm [24]. Values measured in Romani are, in general, comparable to those in literature, indicating similar morphological characteristics and keeping individual habitus. Width of leaves from plants grown in Romani is at the lower, those have grown in the area of origin.

c. Results of measuring the intensity of photosynthesis

The photosynthesis intensity had different values, as shown in Table 2.

The intensity of photosynthsis to *Asimina triloba* and *Ficus benjamini* grown in indoor conditions are presented in Fig. 1-5. Diurnal dynamics of the intensity of photosynthesis was determined and leaves at different levels of a mature tree grown in conditions of outer space to Lăpuşel, near Baia Mare.

Table 1. Germination capacity of the seeds from experimental variants tested.

No. crt.	Substrate stratification	Germination (%) 20-22^{0}C	Germination (%) 28-30^{0}C
1.	Variant 1	57.57%	52.38%
2.	Variant 2	18.18%	19.04%
3.	Variant 3	24.24%	28.57%

Table 2. The intensity of photosynthesis in *Asimina triloba* plants grown in Baia Mare in open space.

Month/coverage of the sky with clouds %			Hour	Basal leaves photosynthesis intesity %			Median leaves photosynthesis intesity %			Upper leaves photosynthsis intensity %		
VII	VIII	IX		VII	VIII	IX	VII	VIII	IX	VII	VIII	IX
0	30	70	9	77	71	74	79	75	73	73	91	69
60	35	70	10	69	72	75	68	69	69	51	72	75
10	35	30	11	70	69	72	71	70	68	68	67	71
70	5	5	12	76	70	61	73	70	22	75	32	71
65	5	65	13	66	65	71	71	58	65	48	20	70
60	60	65	14	75	69	68	76	66	62	76	69	68
50	0	70	15	78	59	70	76	59	60	75	61	66
5	0	25	16	65	18	70	53	33	64	17	22	68
25	25	35	17	61	35	71	53	43	67	30	67	62
65	65	70	18	53	72	69	42	71	65	48	71	67

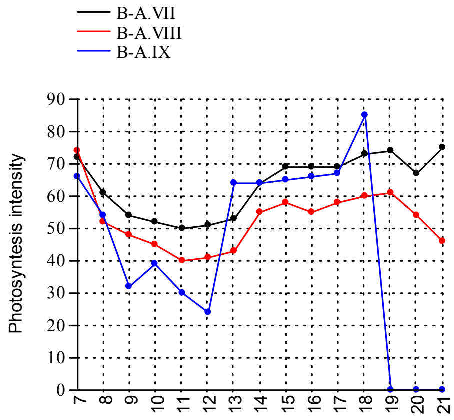

Figure 1. Photosynthesis intensity variations of the *Asimina triloba*.

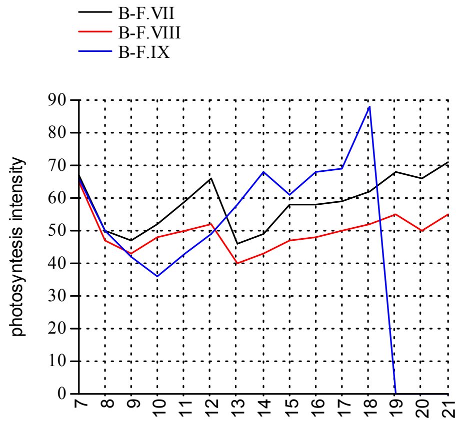

Figure 2. Photosynthesis intensity variations of the *Ficus benjamini.*

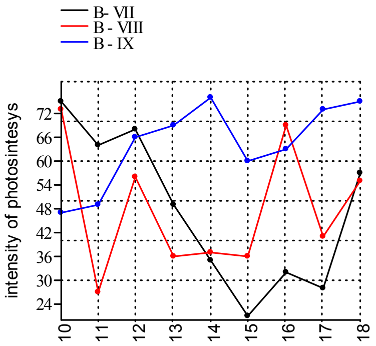

Figure 3. Basal leaf photosynthesis intensity dynamics

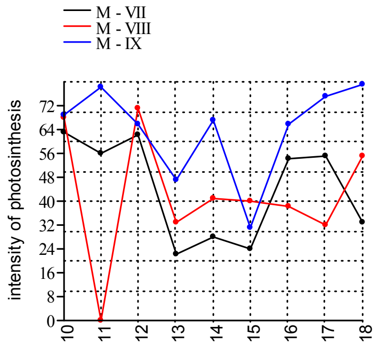

Figure 4. Median leaf photosynthesis intensity dynamics

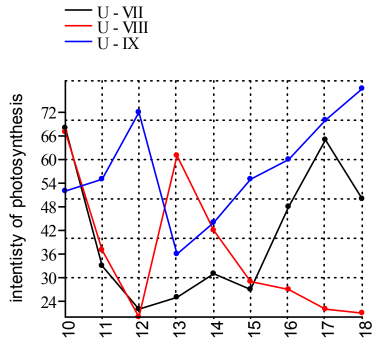

Figure 5. Upper leaf photosynthesis intensity dynamics

DISCUSSION

Introducing a non-native plant species in a new area must be made with caution, because one of the major problems facing ecosystems today is the invasion of species both plant and animal pest. Non-native, invasive plants pose a serious threat to a variety of habitats and ecosystems [17, 18, 19]. These species move aggressively into natural areas creating a dense shrub canopy (monoculture) in some systems [14, 21]. An invasive shrub layer in forests can negatively influence native plant communities in a variety of ways, including the occlusion of light and allelopathic inhibition of native species [19, 22]. As such, the introduction of *Asimina* species in a new area, be approached from two perspectives: a. obtaining and maintaining healthy plants with high ornamental features; b. in the perspective of a possible risk, to change their behavior and become invasive plant. Studies, yet early, will monitor various parameters, such as: morphological and anatomical features, eco-physiological, phenological, and allelopathia behavior.

a. Pawpaw propagation from cuttings is difficult and current clonal propagation is by grafting [10, 11]. Thus, effective alternative for obtaining planting material is germination of seeds. Obtaining seedling from seeds is facilitated by the fact that the individual from Lăpuşel village fructify and produce viable seeds.

Fruit set usually requires cross pollination, which requires at least two genetically different pawpaw trees or cultivars, and the presence of pollinators (flies and beetles). Depending on the variety, fruit ripen in late-August to early-October. Fruit ripen on the same tree over about a 2 week period, which reflects an extended spring flowering period. [4, 25]. Tree growing in Lăpuşel village demonstrates phenological rhythm similar to those individuals from the native habitat in North America. Literature describes the disadvantages of fructification the following: a great variation in fruit size and short shelf-life, caused in part by a small tear in the skin created when fruit are harvested from the cluster, allowing pathogens to enter the fruit [5, 7]. Tree grown in Lăpuşel due to a small vegetation period, does not produce clusters, thus eliminating one of the disadvantages. Fruits are grouped by two or three together, but usually from natural causes in each group, only one reaches maturity. Seeds are usually extracted from the fruit after several days of fermentation in water [13]. Seeds moisture in mature seeds, immediatly removed from fleshy fruits, is about 37% [10, 12].

Seeds diminishes their viability by 50% if theor humidity is reduced by 25-37%. Pawpaw seeds must be stored moist at chilling (5 ^{0}C) temperature, to retain viability in long term storage. Under these conditions seeds retained between 52% and 74% viability [9]. Seeds from Lăpuşel kept their germination capacity between he same limits as those mentioned in the literature. Some references suggest that *Asimina triloba* seeds need to be stratified between 60 and 120 days [10]. Experimentally, we chose a stratification period of 140 days, similar to that during the winter in temperat climates, and especially in Baia Mare. Extension of stratification did not alter the capacity of germination. Variants V1 of the seed stratification generated the best results. However, due to the relatively small number of seeds used, statistical tests were performed to compensate the small sample size. According to them, germination capacity does not depend significantly on the nature of stratification substrate. All three types of substrates used, generated similar results, expressed statisically by Euclidian distance, with values less than 45% (Fig. 6 & 7).

b. Comparing the experimental variants, it is found that the optimal values of morphometric parameters were recorded in combination with chestnuts and evergreen oak. The explanation is found in slow growth of the two species used in combination. Thus in the first two years, do not activate mechanisms of competition between *Asimina*, which grows rapidly and the two species that grow slowly. In combination with shrubs (with faster growth rate), *Asimina triloba,* had a slower growth dynamics (Fig. 8-10).

However, statistically analyzing the results of all experimental variants, there is a pronounced similarity between the results. Euclidian distance expressed by the index value is less than 25%. This finding allows the association of the species in various ornamental combinations, without the risk of poor growth (Fig. 11).

c. In terms of physiological functions, the performance of *Asimina triloba* photosynthesis, in the particular climat conditions of Baia Mare, have been determined. Measurements were performed at: mature tree, 15 years old in Lăpuşel village; in individuals two years old kept outdoors in Baia Mare; individuals two years old raised in protected space (compared with other indoor ornamental species – *Ficus benjamina)*. Graphical reprezentation of the dynamics of photosynthesis, in June- September , registered in plants grown outdoors, show increased performance by over 60% on most leaves and throughout the day (Fig.12).

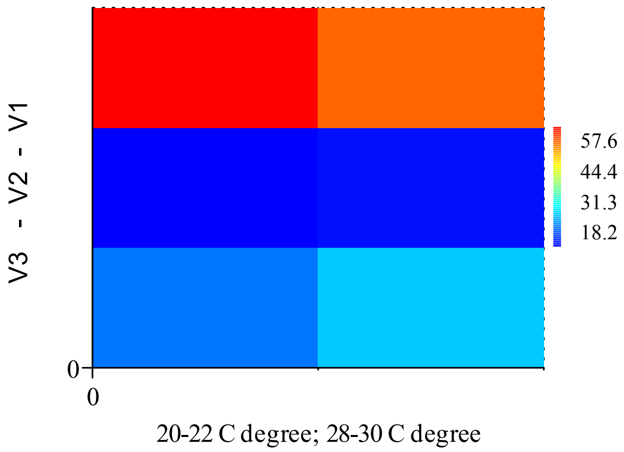

Figure 6. Germination capacity of seeds subjected to different conditions of stratification.

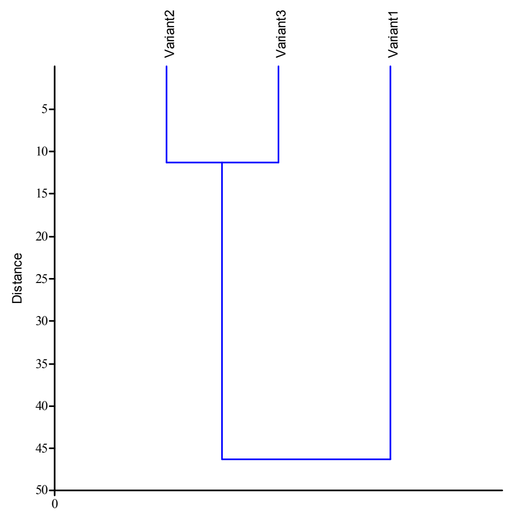

Figure 7. Cluster analysis of the samples tested on the germination capacity.

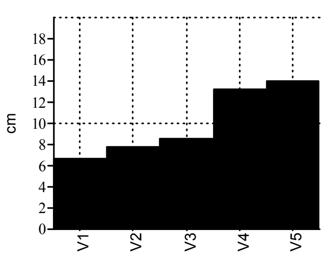

Figure 8. Variations of the leaves length.

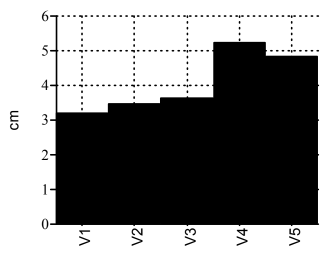

Figure 9. Variation of the leaves width.

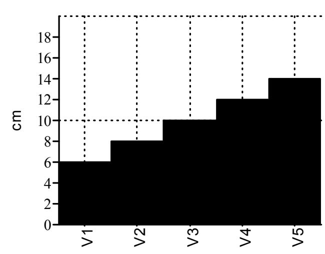

Figure 10. Number of nodes per plant.

Minimum intensity, under 50% were recorded especially in warm months (July, August) and especially to the upper leaves of plants. These results plead for the adaptative capacity of species in temperate climates, and especially in shaded areas, protected from strong heatstroke.

Intensity measurements of photosynthesis in plants grown in outer space Baia Mare revealed the following: in Fig. 13-15 you can see a direct correlation between photosynthesis intensity and the coverage of the sky with clouds. In July, the intensity of photosynthesis is higher in sunny hours and diminishes in that overcast. For August and September, there is a positive linear correlation between sky coverage and intensity of photosynthesis. This suggests an indirect conclusion on the fact that young plants in the early years of vegetation have shade preferences. This behavior observed in the temperate climate of Romania, corresponding to preferences specified for temperate areas of North America [16, 27], which increases the chances of adaptation of the species.

The intensity of photosynthesis was measured also in plants grown indoors. For comparison, the intensity of photosynthesis was measured in ornamental species *Ficus benjamina.* The two species grown together, in the same conditions of temperature, light and humidity, show differences regarding the intensity of photosynthesis (Fig. 17-19).

For both species, exposed to the East, the intensity of photosynthesis is maximum value in September, while in July and in August, the temperatures too high, being a limiting factor. Each month, the two species show different preferences from the light intensity. While the intensity of photosynthesis for *Asimina* is maximum after midday, denoting a kind of shadow preferences, for the *Ficus*, the maximum values of photosynthesis are recorded at noon hours (12-13), indicating a light-loving species, in terms of space pro-

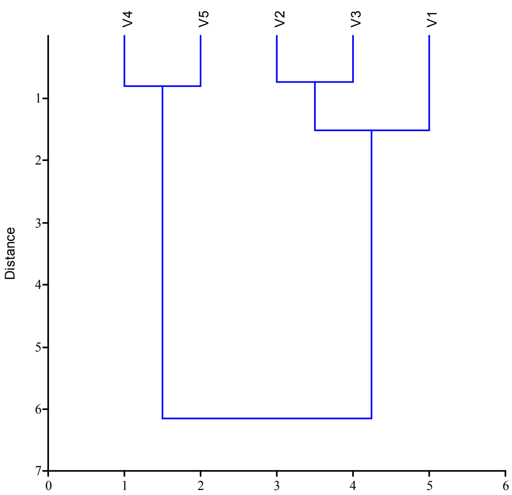

Figure 11. Cluster analysis of morphometric parameters between experimental variants.

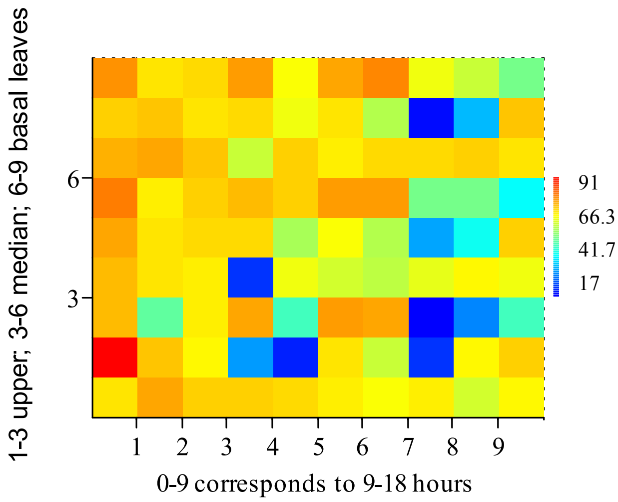

Figure 12. Matrix of photosynthesis intensity to the plants grown outdoors in Baia Mare.

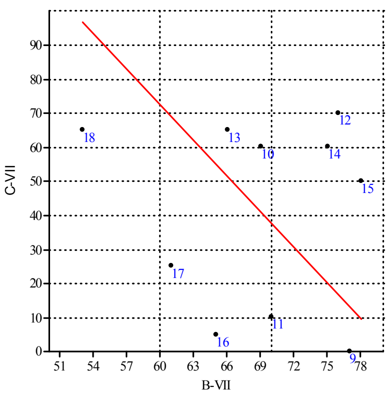

Figure 13. Correlation between photosynthesis intensity and coverage of the sky with clouds in July.

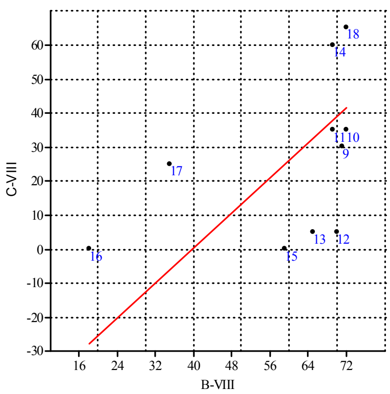

Figure 14. Correlation between photosynthesis intensity and coverage of the sky with clouds in August.

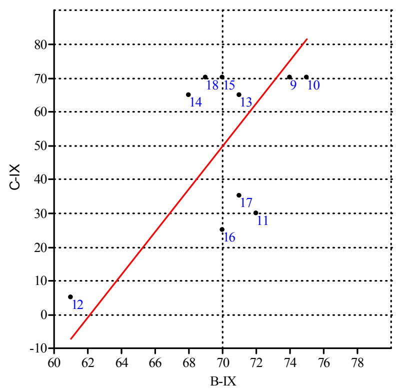

Figure 15. Correlation between photosynthesis intensity and coverage of the sky with clouds in September.

tected in Baia Mare. Although the raw data (Fig. 17-19) show visible differences between the intensity of the photosynthesis of two species, statistical analysis based on Euclidian index, exhibit different things: differences between species are smaller, in terms of Euclidian distance than the differences between data recorded in different months (Fig. 16). Environmental conditions have a bearing on photosynthesis in a greater extent than the characteristics of the species.

Measurement results can recommend *Asimina* species, used as ornamental indoor plant. It prefers more diffuse light, in the afternoon hours.

Following the monthly dynamics of the intensity of photosynthesis in leaves at different levels, it finds that: the photosynthesis intensity is maximum in September, when the period of illumination is sufficient, and the temperature is not so high that they inhibit the process intensity. Unlike, young plants grown in Baia Mare, both in terms of interior and exterior, the intensity of photosynthesis in mature plants, recorded two peaks:

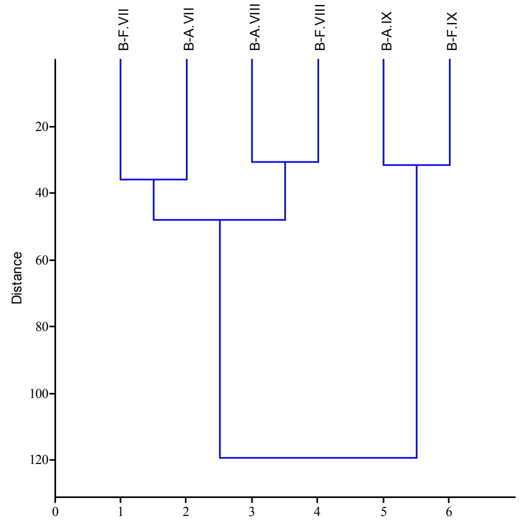

Figure 16. Dendrogram based on Euclidian index of similarity.

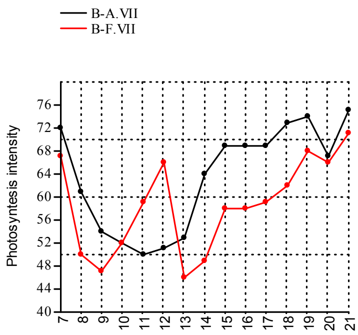

Figure 17. Diurnal dynamics of the photosynthesis intensity to *Asimina* vs. *Ficus* in July. (B-A – *Asimina;* B-F – *Ficus)*

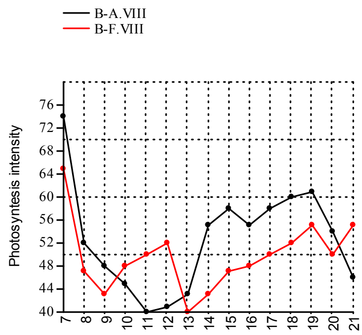

Figure 18. Diurnal dynamics of the photosynthesis intensity to *Asimina* vs. *Ficus* in August.

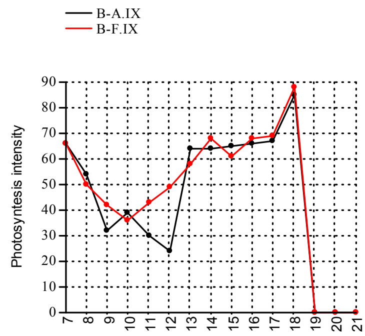

Figure 19. Diurnal dynamics of the photosynthesis intensity to *Asimina* vs. *Ficus* in September.

one in the morning and a second afternoon, with a depression at noon, when the temperature is high. The conclusion is that the adult plant photosynthesis is directly proportional to light intensity, except for the times when the temperature exceeds 30^{0}C. (measured in July, August at lunch times). These findings coincide with studies on photosynthesis intensity in North America , denoting a constant physiological behavior of the reference species [1, 6].

All measurements on the intensity of photosynthesis, carried out at different levels of plant and at different times in correspondence analysis (CA) show very similar values between points results. The points obtained are concentrate in a ellipse with a confidence level of 95% (Fig. 20).

Comparing the intensity of photosynthesis at the tree categories of plants (mature in Lapusel village, open space in Baia Mare, and protected space in Baia Mare), it is found that: the highest intensity of photosynthesis have young plants grown in open space, followed by the mature tree grown in Lăpuşel (Fig. 21-23). Although the species may be increased in the early

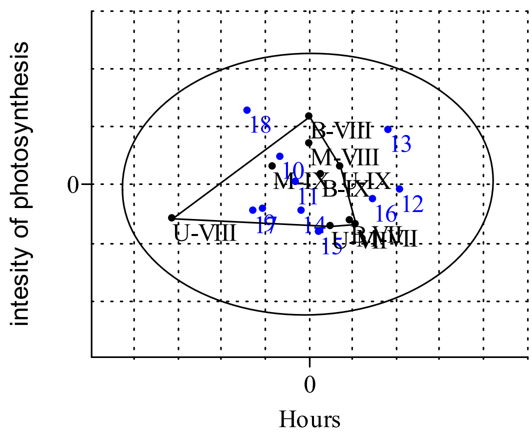

Figure 20. Correspondence analysis of the intensity of photosynthesis

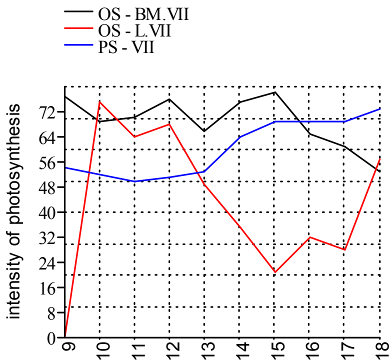

Figure 21. Dynamics of photosynthesis between variants analyzed in July. (OS – open space; BM - Baia Mare, L- Lăpuşel; PS – protected space)

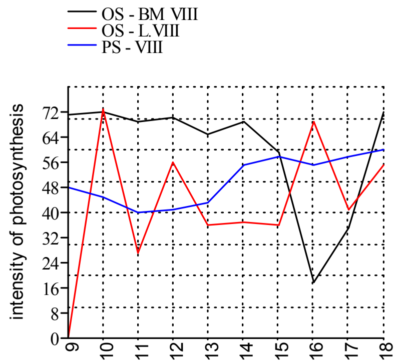

Figure 22. Dynamics of photosynthesis between variants analyzed in August.

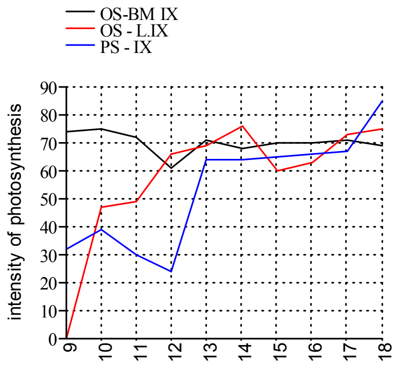

Figure 23. Dynamics of photosynthesis between variants analyzed in September.

stages as ornamental indoor plant, it has better chances of acclimatization in open spaces. Juveniles require shaded areas, while the mature specimens grow well in full sun. Therefore it is recommended that seedlings be planted in sheltered areas, possibly in addition to other protective species (small trees), that *Asimina* triloba overcome them, rising, after 3-4 years.

The landscaping of green spaces in Baia Mare would be improved by introducing *Asimina triloba* (L) Dunal as an ornamental species.

After the second year of vegetation, *Asimina* triloba, begin to develop specific habitus, with chandelier-shaped crown, improving ornamental characteristics. Thus, the species has decorative characteristics from this point, and can be recommended for use in green spaces in Baia Mare.

REFERENCES

[1] Ainsworth, E.A., Davey, P.A., Hymus, G.J., Drake, B.G., Long, S.P., (2002): Long-term response of photosynthesis to elevated carbon dioxide in a Florida scrub-oak ecosystem. Ecological Applikcations 12(5): 1267-1275.

[2] Archbold, D.D., Pomper, K.W., (2003): Ripening pawpaw fruit exhibit respiratory and ethylene Climacterics, Postharvest Biology and Tehnology, 30: 99-103.

[3] Callaway, M.B., (1990): The pawpaw (*Asimina triloba*). Kentucky State University Publication, CRS-HORT1-901T, pp. 48-50.

[4] Callaway, M.B.,(1993): Pawpaw (*Asimina triloba*): A ‘‘tropical’’ fruit for temperate climates, pp. 505–515. In: Janick, J., Simon, J.E., (eds.): New crops, Wiley, New York.

[5] Crabtree, S.B., Pomper, K.W., Lowe, J.D., (2010): Within-Cluster Hand-Thinning Increases fruit weight in North American Pawpaw [*Asimina triloba* (L.) Dunal], Journal of the American Pomological Society 64(4): 234-240.

[6] Crummer, K., (2003): Physiological leaf traits of scrub pawpaw, *Asimina obovata* (Willd.) Nash (Annonaceae), a thesis presented to the graduate school of the university of Florida in partial fulfillment of the requirements for the degree of master of science. University of Florida, pp.10-12.

[7] Darrow, G.M., (1975): Minor temperate fruits, 269-284. In: Janick, J., Moore, J.N., (eds.): Advances in fruit breeding. Purdue University Press, West Lafayette.

[8] McEwan, R.W., Lynne, Ć., Rieske, K., Mary, Ć., Arthur, A., (2009): Potential interactions between invasive woody shrubs and the gypsy moth (*Lymantria dispar*), an invasive insect herbivore. Biology Invasions, 11(4):1053–1058.

[9] Finneseth, C.H., Layne, D.R., Geneve, R.L., (1998): Requirements for seed germination in North American pawpaw [*Asimina triloba* (L.) Dunal]. Seeds Science and Technology, 26: 471-480.

[10] Geneve, R.L., Pomper, K.W., Kester, S.T., Egilla, J.N., Finneseth, C.L.H., Crabtree, S.B., Layne, D.R., (2003): Propagation of Pawpaw – A Review. HortTechnology 13(3): 428-433.

[11] Geneve, R.L., Kester, S.T., Pomper, K.W., (2007): Autonomous shoot production in pawpaw (*Asimina triloba* (L.) Dunal) on plant growth regulator free media. Propagation of Ornamental Plants 7(2): 51-56.

[12] Gorchov, D.L., Trisel, D.E., (2003): Competetive effects of the invasive shrub, *Lonicera maackii* (Rubr.) Herder (Caprifoliaceae), on the growth and survival of native tree seedlings. Plant Ecology, 166(1): 13-24.

[13] Hartmann, H.T., Kester, D.E., Davies, F.T., Geneve, R.L, (2002): Hartmann and Kester's plant propagation: Principles and practices. 7^{th} ed. Pretince Hall, Saddle River, N.J., 928 p.

[14] Hartman, K.M., McCarthy, B.C., (2007): A dendro-ecological study of forest overstorey productivity following the invasion of the non-indigenous shrub *Lonicera maackii*. Journal Vegetation Science, 10: 13-24.

[15] Kral, R., (1960): A revision of Asimina and Deeringothamnus (Annonaceae). Brittonia, 12: 233-278.

[16] Layne, D.R., (1996): The pawpaw [*Asimina triloba* (L.) Dunal]: A new fruit crop for Kentucky and the United States, HortScience, 31: 777-784.

[17] Lovett, G.M., Canham, C.D., Arthur, M.A., Weathers, K.C., Fitzhugh, R.D., (2006): Forest ecosystem responses to exotic pests and pathogens in eastern North America. Bioscience, 56: 395-405.

[18] Mack, R.N., Simberloff, D., Lonsdale, W.M., Evans, H., Clout, M., Bazzaz, F.A., (2000): Biotic invasions: causes, epidemiology, global consequences, and contro., Ecologia Applicata, 10: 689-710.

[19] McEwan, R.W., Rieske, L.K., Arthur, M.A., (2008): Potential interactions between invasive woody shrubs and

the gypsy moth (*Lymanthria dispar),* an invasive insect herbivore. Biol Invasions, 11: 1053-1058.
[20] McLaughlin, J.L. 2008. Pawpaw and cancer: Annonaceous acetogenins from discovery to commercial products. J. Nat. Prod. 71:1311– 1321.
[21] Miller, K.E., Gorchov, D.L., (2004): The invasive shrub, *Lonicera maackii*, reduces growth and fecundity of perennial forest Herbs, Oecologia, 139: 359-375.
[22] Orr, SP., Rudgers, J.A., Clay, K., (2005): Invasive plants can inhibit native tree seedlings: testing potential allelopathic mechanisms. Plant Ecology 181: 153 – 165.
[23] Picchioni, G.A., Graham, C.J., Ulery, A.L., (2004): Gypsum effects on growth and macroelements uptake of field-grown *Asimina triloba* (pawpaw) irrigated with low-saline, sodic water. Hortscience 39(5): 1104-1109.
[24] Pomper, K.W., Layne, D.R., Jones, S.C., Kwantes, M.G., (2002): Growth Enhancement of Containergrown Pawpaw Seedlings as Influenced by Media Type, Root-zone Temperature, and Fertilization Regime, Hortscience 37(2): 329-333.
[25] Pomper, K.W., Crabtree, S.B., Lowe, J.D., (2010): Organic Production of Pawpaw, Kentucky State University Cooperative Extension Program, PBI-004, 6 p.
[26] Pomper, K., Lowe, J.D., Lu, L., Crabtree, S.B., Dutta, S., (2010): Characterization and Identification of Pawpaw Cultivars and Advanced Selections by Simple Sequence Repeat Markers. Journal Americam Society, Horticulural Sciences, 135(2): 143-149.
[27] Warmund, M., (2010): Pawpaws: A Taste of the Tropics. Missouri Environment & Garden, 16(9): 1-2.
[28] Young, D.R., Yavitt, J.B., (1987), Differences in leaf structure, chlorophyll, and nutrients for the understory tree *Asimina triloba*. American Journal of Botany, 74: 1487-1491.

Received: 2 September 2011
Accepted: 25 November 2011
Published Online: 28 November 2011
Analele Universităţii din Oradea – Fascicula Biologie
http://www.bioresearch.ro/revistaen.html
Print-ISSN: 1224-5119
e-ISSN: 1844-7589
CD-ISSN: 1842-6433