ПЛОДОВОДСТВО И ДЕКОРАТИВНОЕ САДОВОДСТВО

УДК: 582.681.41:581.4(555)

VARIATION DIVERSITY IN THE LEAVES OF *PASSIFLORA INCARNATA* L. INTRODUCED FOR THE FIRST TIME IN ABSHERON

Vusala Badalava, Zumrud Mammadova

Azerbaijan Ministry of Sciences and Education, Institute of Dendrology, Azerbaidjan, Baku, Esenina Sergeya str., 89
E-mail: drvusalabadalova@gmail.com

During plant development, leaves undergo various ontogenetic changes, including differences in size, shape, and geometric dimensions. An in-depth study of morphological traits showed differences in species and populations according to adaptive traits. The *Passiflora incarnata* L. species of the *Passiflora* genus undergoes heteroblastic-significant changes as it grows and develops, showing a morphological distinction between young and mature vegetative phases. Morphological polymorphism of the leaves of *P. incarnata* L., one of the most promising species introduced to Azerbaijan and grown under *in open* and *in closed* conditions, was studied and analyzed mathematically. The leaf area was 135.8 cm^2 under *in open* conditions and amounted to 105.5 cm^2 under *in closed* conditions; the perimeter of the leaf under *in open* conditions was 367.48 cm, while in plants grown under *in closed* conditions this parameter was 355.6 cm. The morphological characteristics of the leaves were found to be higher in the samples grown under *in open* conditions compared to the *in closed* conditions. However, in addition to the leaf perimeter, diversity observed in other morphological traits and the coefficient of variation were higher in plants developed under *in closed* conditions compared to those grown *in open*. This is attributed to the greater stability of abiotic factors under *in open* conditions compared to *in closed* conditions. The high variance indicates the high adaptability of the *P. incarnata* L. species.

Key words: *parameter; variation; introduction morphometric analysis; heteroblast; population*

Introduction

Passiflora incarnata L. commonly know as maypop, is a species that has created considerable interest as a crop because of its large, colorful and sweet-scented flowers as well as its edible fruits containing an aromatic juice (Vanderplank 1996), which has been found to be rich in sugar (Arjona, Matta and Garner, 1991). *P. incarnata* L. is a native of South America and can grow in both tropical and subtropical climates. *Passiflora* having creeping and climbing lianas belongs to the family *Passifloraceae* of the order *Violes*. It grows naturally in tropical America, Asia, and Australia (Patel, 2009).

Passiflora incarnata is one of the 500 species belonging to the genus Passiflora and a tropical fruit crop known as passion fruit (De Wilde, 1971; Cronquist, 1988). It has been used by Asian peoples as a medicinal plant to treat anxiety, depression, and insomnia (Lorenzi and Matos. 2002). There are species in the world belonging to the genus *Passiflora* that are used in different forms (ornamental, medicinal, edible fruits) (F.Uzunoghlu and K. Mavi, 2017). *Passiflora caerulea* is widely used in landscape architecture as an ornamental plant in Azerbaijan. In the pharmaceutical industry, *Passiflora incarnata* L. species has been used for many years as a sedative and antidepressant drug (Y. Karimov, et al., 2010). Most of these species are native to the United States and South America, including Argentina, Brazil, Colombia, and Paraguay. On the South-Eastern Asian continent, it grows naturally in Australia and China. In Brazil, 89 species of Passiflora are endemic and therefore, it is considered the home of biodiversity (Serqueira-Silva et al, 2014).

An optimal environmental condition is the main stimulus for the normal growth and development of the organism. In this regard, three factors should be noted: temperature, humidity (moisture), and wind speed. It is these three factors that characterize the microclimate

conditions of the area, and the creeping plants grown in the area have a special role in their regulation (O. Ibadly. A.Mehraliyev.p.188., Baku 2012).

Fig. 1 *P. incarnata* L. species view

Picture 1 is a species with leaves arranged in a leaf mosaic pattern without overshadowing one another. A characteristic feature of leaf mosaic is to ensure that the same amount of light falls on the leaves on the same plane. The mosaic arrangement of the leaves can be seen in almost all lianas. The different shapes and sizes of the leaf blades and stalks, the angle of their alignment in the ortostih, the split leaf blade, etc. allow active photosynthesis by maximum use of light rays.

In the same sprout, the leaves have different structures and can form a three-layered formation. Those in the lower part of the sprout are the bottom leaves, the middle leaves are more active in photosynthesis, and those around a flower group are called top leaves. When describing the leaves, the focus is on the middle leaves. Because the middle leaves contain all the general features of the leaves in the habitus of the plant (Z. Humbatov 2017).

The variation observed in leaf morphology is a key indicator of plant adaptation to different environmental conditions.

To assess the diversity in the population belonging to the *Passiflora* genus of the *Passifloraceae* family, we analyzed the variation of the morphological and functional characteristics of the leaves in the areas where the species was introduced. For this purpose, leaf samples were taken from *in open* and *in closed* populations species introduced in the experimental field of the Institute of Dendrology. Azerbaijan Ministry of Sciences and Education**,** in 2018.

These plants are heteroblastic species (Cutri et all., 2013). Heteroblastic means the presence of different leaf shapes on a plant (Plotze et all., 2005; Chitwood and Otoni, 2017 *b*).

The transition from the juvenile to the mature stage is manifested by changes in leaf morphology over time as the growth meristem, commonly known as the heteroblasty (apical). These morphological changes are connected to changes in plant hormones and the chemical composition of the leaf (Silva et all., 2019).

The color of the cultivated *Passiflora incarnata* changes from yellow-green to dark-green depending on the species.

Many researchers studied the leaf diversity of Passiflora species (Daniel H. and Wagner, 2017; Amanda Mendes Fernandes et all., 2020). Various conclusions were drawn in these studies. Goebel K. (1908) stated that heteroblasty occurs because the process of photosynthesis in plants during the development of newly formed leaves does not fully provide the plant with nutrients. Some researchers report that in the populations of the *Passiflora* species, all the first leaves are similar and that heteroblastic changes occur in the structure of the subsequent leaves. Gilbert (1982) concluded that in *Passiflora*, heteroblasty is a mechanism for escaping *Heliconius* (*Heliconius charithonia*) butterflies that used leaves to lay eggs.

The plants af genus Passiflora are shrubs and herbs, mostly climbers with auxillary tendrils, Stem is herbaceus or woody, generally climbing, very rarely arborescent. Leaves alternate, sometimes compound, imparipinnate; stipules germinate at the base of petioles, rarely absent; tendril axillary, arising from sterile pedicels. Flowers are bisexual or unisexual, regular. The large receptacle is often hollowed out like a cup or basin, and bears numerous filamentous granular appendages between the corolla and stamens, which may be brightly colored and form a conspicuous corona of great diversity.

The plants of this species were first introduced to Azerbaijan by us. The introduction was successful, phenological observations were made at all stages of ontogenesis. We aimed to study the diversity observed in the leaves of *P. incarnata* L. species under *in open* and *in closed* conditions and to assess the adaptive potential of the species.

Materials and Methods

We started the first introduction of *Passiflora* species in Azerbaijan in 2018 using seeds imported from Florida. During the season, all stages of ontogenesis were studied, phenological observations were made by various methods. The species adapted well to Absheron conditions.

The Absheron Peninsula, where the study was conducted, is located at 40˚77˙ and 40˚37˙ north latitude and 49˚30˙-50˚22˙ south longitude. The length of the peninsula is 80 km from north to west, the widest width is 27 km, the middle part is 22 km. The total area of the peninsula is 2050 km^2. The climate of Absheron is included in the subtropical climate zone with dry and very hot summers, warm and mild autumns, and short winters (T.S.Mammadov, 2010).

To study the variability of morphological features of leaves, 100 leaves were collected from 10 plant samples, 10 leaves each (Jensen, 1990). Leaf samples collected from mature forms should be used for the biometric analysis of leaves because samples from young offshoots and seedlings are very similar or even indistinguishable (Baratynski et al., 2008). Six morphometric parameters (LL-leaf length, LW-leaf width, LSA-leaf surface area, LP-leaf perimeter, F-leaf shape coefficient, and R - leaf length to width ratio (R = LL / LW)) were measured in the collected leaves using CI-202 LESER AREA METER (USA) (Figure 1). Measurements were carried out at the Institute of Dendrology in Azerbaijan Ministry of Sciences and Education**,**. The measurement results were mathematically analyzed (R. Guliyev and K. Aliyeva, 2002).

Fig. 2 CI-202 Leser area meter

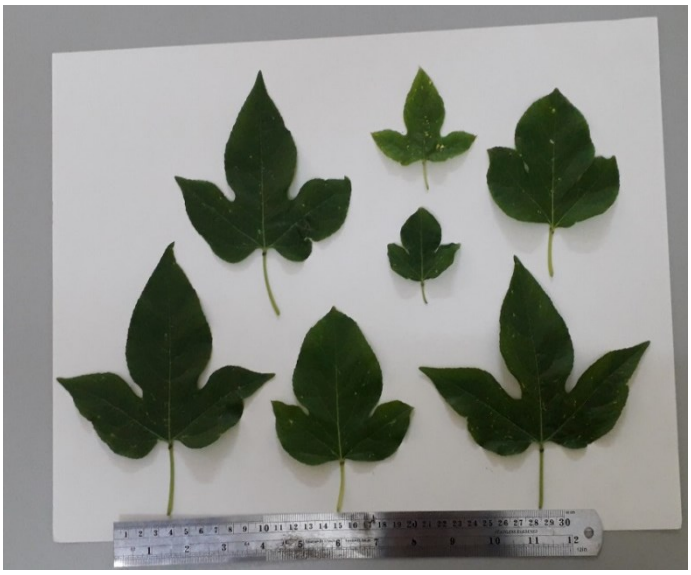

Fig. 3 Heterophylia of *P. incarnata* L leaves

Raw data are worthless until they are processed by computer systems for a specific purpose and turned into knowledge. The traditional method of transforming information into knowledge is based on classical analysis and interpretation. Compilation and mathematical analysis of the variation order according to the morphological features of the leaf, the centralization of the figures, and their preparation for further analysis were implemented using the computer program Excel. To characterize the variation order, the comparison of the studied material with other materials can be carried out after determining the average mathematical parameters of the variation order ($\bar{x}$)

$$\bar{x} = \frac{\sum xf}{n} \quad (1)$$

The average mathematical index of morphological features characterizes the basis of modification variability. The average mathematical value differs the least from other dimensions in the variation order. The second parameter of the variation order, standard deviation (σ) was used to correctly characterize the variability. The standard deviation is calculated by the following formula:

$$\mathfrak{I} = \pm\sqrt{\frac{\left(x-\bar{x}\right)^2 f}{n-1}} \quad (2)$$

The standard deviation shows, on average, how much each variation differs from the mathematical mean. Sigma (σ) is a measure of modification variability. The coefficient of variation is used to compare the variability observed in different traits in a population:

$$CV = \frac{\sigma}{\overline{X}} * 100\% \quad (3)$$

Results and discussion

Variation in leaf morphology is a key indicator of plant adaptation to environmental conditions. The structure and functions of a leaf can change due to evolution when it adapts to certain conditions. To assess the diversity in the population of the researched species, which are of the *Passiflora* genus belonging to the family *Passifloraceae*, we analyzed the variation of the leaf morphological characteristics in the areas where the species was introduced.

Higher morphological indices of the leaves were observed in plant samples grown under *in open* in Absheron conditions. Besides, heterophyllia – the different structure of the leaves in

the habitus of plants - was more pronounced under *in open* conditions. Thus, under *in open* conditions, the leaves at the top are more split and subjected to sunlight compared to the leaves below, which in turn facilitates the adaptation of the introduced plant to local conditions.

Morphological traits of leaves were found to be higher in plant samples grown under *in open* conditions compared to those under *in closed* conditions. For example, the leaf area was 135.8 cm^2 under *in open* conditions and amounted to 105.5 cm^2 under *in closed* conditions; The perimeter of the leaf under *in open* conditions was 367.48 cm, while in plants grown under *in closed* conditions this parameter was 355.6 cm (table). However, in addition to the leaf perimeter, diversity observed in other morphological traits and the coefficient of variation were higher in plants developed under *in closed* conditions compared to those grown *in open*. . According to the perimeter of the leaf, the coefficient of variation under *in open* conditions was 31.17%, while under *in closed* conditions, it amounted to 10.34%. Based on the perimeter of the leaf, the coefficient of variation under *in open* conditions was 31.17%, and under *in closed* conditions it was10.34%. The greatest variation in leaves was observed in the width to length ratio (R = LL / LW) (CV = 109.2.%) in plants grown *in closed*, and the least variation was found in the same ratio of the plants grown *in open* (R = LL / LW) (CV = 7.54%) (table).

Passiflora species differ from trees and shrubs in many respects because of their creeping stems. They grow quickly, spread more in areas where trees and shrubs are difficult to grow, and quickly "occupy" the area where they grow by developing in a vertical and horizontal direction.

The above-mentioned properties of creeping plants greatly expand the scope of their use. Thus, they protect the area from noise, harmful dust mixtures, strong winds, etc. and they are widely used in the improvement of microclimate conditions, biological recultivation of soils, medicine, and the food industry.

The role of *Passiflora* species with a creeping stem as a surface cover should be noted, especially in forestry and soil erosion protection.

Table

Morphological variations of *Passiflora incarnata* L. leaves grown in open (control) and closed conditions

Morphological traits		$\bar{x}$	σ	CV(%)
Area (cm^2)	A_k	135.8	±20.18	13.98
	A	105.5	±21.2	19.8
Length (cm)	L_k	22.385	±2.18	7.64
	L	21.5	±11.4	44.56
Perimeter (cm)	P_k	367.48	±130.51	31.17
	P	355.6	±33.3	10.34
Width (cm)	W_k	13.71	±3.38	27.47
	W	13.29	±6.1	93.94
Ratio	R_k	1.55	±0.11	7.54
	R	1.63	±1.7	109.2
Factor	F_k	0.06	±0.002	
	F	0.023	0.01	29.53

Fig. 4 a) in open conditions

b) in closed conditions

According to our research, variations in the structure of *P. incarnata* L. leaves are often related to the growing conditions of the species. Like other organs, the variety of shapes of the leaves is due to the differentiation of growth, i.e. the diversity between the different rates of growth of the leaf in various directions. The high variability indicates the high adaptability of *P. incarnata* L.

Our country is one of the countries in the world with high economic potential, where many types of fruits can grow due to geographical location and ecological features. *P. incarnata* L. is a tropical fruit known in foreign countries as maypop. It is very popular and has different uses. This species, which attracts attention in the world due to its nutritional value and use in the field of pharmacy, can be easily cultivated in some regions of our country.

Fig. 5 Leaf heterophyllia in the *P. incarnata* L. species

Passiflora incarnata L. is widely used in the medical industry and because it is a very important species for landscape architecture due to its decorativeness. This is a new tropical species introduced in Azerbaijan, and therefore it is economically and scientifically important

to conduct research through the production and adaptation of the species to suitable environmental conditions. In the course of our research, the adaptation of the species to different locations: its reaction to the growing environment, the ability to bear fruit based on productivity and quality indicators were studied in depth.

Based on the result we received, the adaptability of the species was high.

According to the results of our research, the variations in the structure of the leaves of P.incarnata L. are mainly related to the ripening conditions of the species. The high diversity of variation in the leaves of the plant under open conditions indicated the possibility of the introduction of P. incarnata L. in Absheron.

References

Harvey E.A., Frank B.M., and James O.G., Jr. Department of Horticulture, *P.O. Drawer T.*, Missippi State, MS 39762 // *HortScience*. 1991. 26(7). P. 921–923.

Fernandes A.M., Fortini E.A., de Carvalho Müller L.A., Batista D.S., Vieira L.M., Silva P.O., do Amaral C.H., Poethig R.S., Otoni W.C. Leaf development stages and ontogenetic changes in passionfruit (*Passiflora edulis* Sims.) are detected by narrowband spectral signal // *Journal of Photochemistry and Photobiology* B: Biology. 2020. Vol. 209. P. 111931

Barbalho S.M., Savza M.S.S., Silva J.C.P., Mendes C.G., Oliveira G.A., Costa T. and Machado F.. Yellow Passion Fruit Rind *(Passiflora edulis*): an Industral Waste or an Adjuvant in the Maintenance of Glycaemia and Prevention of Dyslipidemia // *Journal of Diabetes Research and Clinical Metabolism.* 2012. Vol. 14. P. 1-5.

Boratynski A., Marcysiak K., Lewandowska A., Jasinska A., Iszkulo G. & Burczyk J. Differences in leaf morphology between *Quercus petraea* and *Q. robur* adult and young individuals // Silva Fennica. 2008. Vol. 42. No 1. P. 115–124.

Vanderplank J. Passiflora Quadrifaria Passifloraceae. MIT Press. UK, 1996. P. 63–69.

Busilacchi H.C., Severin M., Gattuso A., Aguirre O., Di Sapio and Gattuso S. Field Culture of Micro propagated *Passiflora caerulea* L. // Historical and Chemical Studies. Redalyc Sistema de Informacion Cientifica. 2008. Vol. 7. No 5. P. 257-263.

Cerqueira-Silva C.B., Jesus O.N., Santos E.S.L., Correa R.X., Souza A.P. Genetic Breeding and diversity of the genus *Passiflora:* Progress and perspectives in molecular and genetic studies // International Journal of Molecular Sciences. 2014. Vol. 15. P. 14122-14152.

Cronquist A. The evolution and classification of flowering plants, 2nd edn. New York: New York Botanical Garden, 1988.

Cutri L., Nave N., Ami M.B., Chayut N., Samach A., Dornelas M.C. Evolutionary, genetic, environmental and hormonal-induced plasticity in the fate of orqans arising from axillary meristems in *Passiflora spp.* // Mechanisms of Development. 2013. Vol. 130. P. 61–69.

De Wilde W.J.J.O. The systematic position of the tribe Paropsieae, in particular the genus Ancistrothyrsus, and a key to the genera of *Passifloraceae* // Blumea. 1971. P. 99–104.

Gilbert L.E. The coevolution of a butterfly and a vine // Scientific American. 1982. Vol. 247. P. 110–121. Doi: 10.1038/ scientificamerican 0882–110.

Goebel K. Einleitung in die experimentelle Morphologie der Pflanzen. 1908.

Jensen R.J. Detecting shape variation in oak leaf morphology: a comparison of rotational-fit methods // American Journal of Botany. 1990. Vol. 77. No 10. P. 1279–1293.

Guliyev R., Aliyeva K. Genetics. Baku: Publication of Baku University, 2002. 396 p.

Lorenzi H., Matos F.J.A. Plantas medicinais no Brasil: nativas e exoticas. Nova Odessa: Instituto Plantarum de Estudos da Flora, 2002. 544 p.

Ibadli O.V., Mehraliyev A.D. Baku-2012. In the Climbing Plants Question. 222 p.

Patel S.S., Saleem M., Ravi V., Shrestha B., Verma N.K. and Gauthaman K. Passiflora incarnata Linn: A Phytopharmacological Review // International Jurnal of Green. 2009.

Plotze R.D.O., Falvo M., Padua J.G. et al. Leaf shape analysis using the multiscale Minkowski fractal dimension, a new morphometric method a study with *Passiflora* (*Passifloraceae*) // Canadian Journal of Botany. 2005. Vol. 83. P. 287–301.

Silva G.F., Silva E.M., Correa J.P. et al. Tomato oral induction and ower development are orchestrated by the interplay between gibberellin and two unrelated micro RNA – controlled modules // New Phytologist. 2019. Vol. 211. P. 1328–1344.

Mammadov T.S. Trees and shrubs of Absheron. Baku, 2010. P. 468.

Turemiş N. A New Grape Fruit "Passionflower" and Its Economic Importance. IV. National Symposium on Berries, 03-05 October 2012 Antalya, 23 p. Leipzig, Germany: Teubner B.G. Pharmacy. 2012. pp: 277.

Uzunoğlu F. and Mavi K. A Medical Miracle; Passionflower (*Passiflora* spp.) Plant. International Mesopotamia Agriculture Congress, 22–25 September. 2014. 620 p.

Karimov Y., Suleymanov T., Isayev C., Xalilov C. *Pharmacoqnozia*. Baku, 2010. 738 p.

Humbatov Z. Plant morphology and anatomy (textbook). Baku:'' Apostroff, 2017. 692 p.

Статья поступила в редакцию 12.01.2024 г.

Бадалава В., Мамедова З. Морфометрические показатели листьев вида *Passiflora incarnata* L., впервые выращенных в Азербайджане // Plant Biology and Horticulture: theory, innovation. 2024. №. 3 P. 7-14

В процессе развития растений в листьях происходит различные онтогенетические изменения, в том числе имеются различия в размерах. Углубленное изучение морфологических признаков показало различия видов и популяций по адаптивным признакам. Вид *Passiflora incarnata* L. рода *Passiflora* претерпевает значительные гетеробластические изменения по мере роста и развития, демонстрируя морфологическое различие между молодой и зрелой вегетативными фазами. Изучен и математически проанализирован морфологический полиморфизм листьев *Passiflora incarnata* L., одного из наиболее перспективных видов, интродуцированных в Азербайджан и выращиваемых в условиях открытого и закрытого грунта. Площадь листьев в условиях открытого грунта составила 135,8 см^2, в условиях закрытого – 105,5 см^2; периметр листа в условиях открытого грунта составил 367,48 см, тогда как у растений, выращенных в условиях закрытого грунта, этот параметр составил 355,6 см. Установлено, что морфологические характеристики листьев выше у образцов, выращенных в условиях открытого грунта, по сравнению с условиями закрытого грунта. Однако, помимо периметра листа, разнообразие по другим морфологическим признакам и коэффициент вариации были выше у растений, выращенных в условиях закрытого грунта, по сравнению с растениями, выращенными в открытом грунте. Это объясняется большей стабильностью абиотических факторов в условиях открытого грунта по сравнению с условиями выращивания в закрытом грунте. Высокая дисперсия указывает на высокую адаптивность вида *Passiflora incarnata* L.

Ключевые слова: *параметр; вариация; интродукционный морфометрический анализ; гетобласт; популяция*