

# БОТАНІКА

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## **PECULIARITIES OF BIOLOGY OF FLOWERING OF PROTANDROUS AND PROTOGENIC *JUGLANS REGIA* L. INDIVIDUALS IN CONNECTION WITH DICHOGAMY**

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Results of research of biology of flowering of *Juglans regia* L. of protandrous and protogenic individuals in connection with dichogamy are given in the article. Peculiarities of individuals flowering, depending on climatic factors (temperature and humidity of the air, precipitation, illumination) were analysed in conditions of Western Podillya (Ternopil region). It was established that dichogamy in the kind of *Juglans* L. appeared during evolution of the vegetable kingdom as adaptation to the cross-pollination.

*Key words:* dichogamy, protandry, protogyny, biology of flowering, climatic factors, *Juglans regia*

Dichogamy (from Greek *dicha* – into two parts, separately and *gamos* – marriage) – non-simultaneous after ripening of anthers and stigmas in flowers. Dichogamy as adaptation to the cross-pollination was described by A. T. Bolotov for the first time [2]. The term dichogamy was suggested by Sprengel in 1773 year. Anthers (proterandriya) ripen at first in one kind of flowers, but stigmas (protogyny) ripen in the other flowers. Dichogamy is observed not only in monoecious, but also in unisexual flowers of monoecious and dioecian plants [3]. There are two types of dichogamy: accomplished, when stigmas ripen after parching of stamens (or vice-versa) and not accomplished, which appears because of not lost function of organs of opposite sex. Protandry is observed almost in all plants of *Asteraceae* Dumort., *Fabaceae* Lindl., *Ranunculaceae* L. family and others. Protogyny is observed more rarely, for example, in plants of *Berberidaceae* L., *Brassicaceae* Burnett., *Rosaceae* Juss. family and others. For the first time phenomenon of dichogamy in the kinds of *Junglas* L. genus was described by F. Delpino [17] on the example of *J. regia*.

### **Material and research methods**

Individuals of Circassian walnut, that grow on the territory of fruit garden of agrobiological laboratory of Ternopil national teachers' training university named after Volodymyr G. were taken as object of research. 9 trees (4 – protandrous, 5 – protogenic) were chosen to carry out observations of flowering character (beginning of flowering, mass flowering, end of flowering, duration of flowering). Researches of biology of flowering were carried out during two years on the same individuals, which were marked with proper labels beforehand. Observations of flowering of certain flowers and inflorescences were carried out on five chosen with that purpose generative cuts of each individual.

Phases of flowering (beginning of flowering, mass flowering, duration and end of flowering) were studied by the methods of A. N. Ponomarev [8] and M. M. Barni [2]. Besides that sequence of flowers opening and quantity of open flowers within inflorescence, duration of flowering of certain

flowers, inflorescences, individuals were established. Data, taken from <http://rp5.ua/archive.php>, about temperature of air, its relative humidity and precipitation, was used to determine dependence of these processes from meteorological factors.

Beginning of flowering of male individuals was considered such a state of male aments when first anthers appear in blossom cluster. When touching them pollen was left on the fingers. Beginning of flowering of female individuals was considered such a state of pistils when stigmas with formed lobes were noticed under the blanket of bracts. Period of mass flowering of male flowers was considered such a state when all male flowers in aments produced pollen. End of flowering of male flowers was characterized by blossom fall of male flowers and aments. End of flowering of female flowers was characterized by presence of dry stigmas which can't make conditions for germination of pollen.

### Results of research and their review

Starting research of biology of flowering of generative organs, we came from the fact that *Juglans regia* according to data [7] is concerned to phenogroup as per the period of flowering of polycarpic tree plants – average blossoming (21.04-23.05) and to phenogroup as per duration of flowering to the period of blossoming – short (8-14 days). Having analysed data of research of terms of efflorescence of *Juglans regia* individuals and duration of flowering (period of flowering) taking into consideration meteorological conditions of Western Podillya (Ternopil region) and coming from proposed classification of phenogroups of polycarpic tree plants [7], we established that *Juglans regia* belongs to average blossoming kinds which blossoms in the first decade of May and continues to bloom to the middle of the third decade of May with short period of flowering.

Throughout two years of research according to the biology of *Juglans regia* flowering in conditions of Ternopil region certain appropriateness concerning blossoming of individuals of examined kind, was established. *Juglans regia* is characterized by morphological peculiarities of stamen and utricle flowers that considerably influence process of flowering. Stamen and utricle flowers blossom non-simultaneously on one and the same individual. Cases of simultaneous blossoming of male and female flowers on one and the same tree were observed very seldom. At first, male flowers blossom on one and the same individual. Then in the end of their flowering, female start to bloom. On others - vice-versa at first female flowers blossom, then male flowers start blooming. Such appropriateness of blossoming of male and female flowers rules out their self-pollination and provides cross-pollination. Blossoming of male flowers happens more intensively than female, and ends in short term. During cross-pollination male generative sphere of most polycarpic plants produces more pollen than stigma of utricles that female generative sphere produces to its taking. It provides more probability of hitting of pollen to the stigmas of utricle during anemophilous pollination. Interval between blossoming of male and female flowers is 6-10 days. Such peculiarity of flowering is typical for dichogamous plants, which object of our research *Juglans regia* belongs to.

Question concerning constancy of type of flowering of *Juglans regia* still stays disputable. Some scientists consider that type of flowering of one individual persists permanently, others think that type of dichogamy can change because of climatic conditions.

According to data of N. A. Orlova [8] it is very difficult to make out forms of Circassian walnut by morphological characteristics to their flowering. During the first year of blossoming only female flowers and sometimes stamen appear in most individuals. During the second year number of stamen flowers increase, but female dominate. And only during the third year proper form of flowering of this or that individual is settled. Protandrous and protogenic individuals are spread in plantations approximately evenly. Results, carried out by abovementioned author of research, also showed that protandrous individuals a little bit predominate over protogenic one in grown-up individuals of Circassian walnut. As far as young individuals are concerned, which have recently entered into the period of fructification, considerable predominance of number of protogenic individuals to protandrous is observed.

According to P. L. Dorofeev's observations [5], separately growing protogenic individuals of Circassian walnut give more often crops than separately growing protandrous individuals. This fact is explained by self-pollination of protogenic individuals, because their female flowers keep life activity

till ripening of pollen of their aments. So vicinity of other Circassian walnut trees is necessary for protandrous individuals more than for protogenic one.

Heredity of this or that type of dichogamy is not examined much. Studying genetics of this phenomenon, O. D. Mayatska ascertained that each individual of Circassian walnut can make group of descendants that are distinguished by the type of dichogamy to protandrous and protogenic individuals [11]. Walnut garden from seeds taken from 30 trees was created in 1951 year on Volodymyrivska agro forest land improvement research station (Mykolaiv region) by methods of F. L. Schepotiev to study this question. Area of the garden was 5 ha. Seeds from each tree were separately sowed. That gave opportunity to grow descendants from nut trees with certain type of dichogamy. Descendants of maternal trees began to fructify regularly from 10 years age. Such method of formation of Circassian walnut population allowed to distinguish young trees according to the types of dichogamy. Record of protogenic and protandrous nut trees in the garden was carried out in 1965 year in the period of blossoming. Descendants of Circassian walnut are 1024 young trees, where 537 (52%) of individuals are protogenic and 487 (48%) are protandrous. Researches which were carried out, indicate that Circassian walnut gives descendants, that are divided according to the types of dichogamy into protandrous and protogenic individuals. Their number can be approximately the same or with little deviation.

So, it can be inferred from literary data, that protandry and protogyny are inherently fixed characteristics that are passed by certain hereditary factors in chromosomes of Circassian walnut. Quantitative reveals of dichogamy in monoecious Circassian walnut are similar to the character of descendants' differentiation by the signs of sex in other monoecious tree breeds.

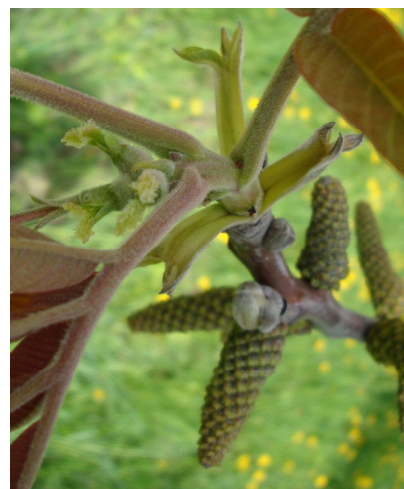
Our two years researches of this question are confirmed with literary data, because we observed constancy of dichogamy type in one and the same *Juglans regia* individuals. Despite changes of climatic conditions during the period of research male generative sphere of protandrous individuals and female of protogenic one always came first into phase of flowering (picture 1). Such appropriateness is also observed in the process of flowering. Data that we receive is confirmed by literary data about the fact that dichogamy is hereditary sign, peculiar to monoecious Circassian walnut. Change of climatic conditions influences only change of terms of beginning and duration of flowering of *Juglans regia* individuals.



Picture 1. Protogenic (on the left) and protandrous (on the right) *Juglans regia* individuals in the period of flowering in the garden of agro biological laboratory of Ternopil teachers' training university named after Volodymyr Gnatuk (11. 05. 2011 year)

During three years of researches appropriateness of blossoming beginning of protandrous and protogenic *J. regia* individuals was established [9, 10]. This appropriateness consists of the following. Each year male generative sphere of protandrous individuals came into phase of flowering averagely 8-10 days faster than male generative sphere of protogenic individuals (picture 2). Moreover this appropriateness was observed even because of different climatic factors (temperature, humidity of the

air and precipitation). So, in 2010 year male generative organs came into phase of flowering on the 3<sup>rd</sup> of May, and protogenic one on the 11<sup>th</sup> of May. In 2011 male flowers of protandrous individuals starts blossoming on the 3<sup>rd</sup> of May, and protogenic one on the 18<sup>th</sup> of May, in 2012 properly – the 2<sup>nd</sup> and the 8<sup>th</sup> of May. Analysis of climatic factors for the periods of flowering of protandrous individuals showed that average daily temperature and humidity of the air during these periods were the following: in 2010 year – + 15,41 °C and 59,25%; in 2011 year - + 11 °C, 62%; in 2012 year - +17,2 °C, 52,6%. It can be inferred from the given data that during the years of research male generative sphere of protandrous individuals came into the phase of flowering the most quickly in 2012 year (the 2<sup>nd</sup> of May), and the latest – in 2011 year (the 11<sup>th</sup> of May). Accordingly analysis of climatic factors during the period of flowering of protogenic individuals showed that temperature and humidity of the air during these periods were the following: in 2010 year +14,41 °C and 66,1%; in 2011 year + 15,1 °C and 66,3%; in 2012 +15,2 °C, 87%. So, it can be inferred from the given data that during the years of researches male generative sphere of protandrous individuals came into the phase of flowering the most quickly in 2012 year (the 8<sup>th</sup> of May), and the latest – in 2011 year (the 18<sup>th</sup> of May).



Picture 2: Male aments of protandrous (a) and protogenic (b) *Juglans regia* individuals in the period of coming into the phase of flowering (the 11<sup>th</sup> of May 2011 year)

Aments, that were placed below on the cut, blossomed out the first, afterwards those which were placed closer to the top of the cut. According to the literary data one ament blossoms for 1,5-2 days, and because of sunny warm weather all pollen from the ament spills out during one day [13, 14]. According to our observations male aments blossomed for 2-4 days, because in the period of flowering there was cold rainy weather. Mass flowering of the examined kind starts on the 4-6<sup>th</sup> day from the beginning of the blossoming. Number of flowers that opened sharply decreases in rainy weather, but this process does not stop completely (picture 2). In these conditions anthers first opened on the sunny side of the ament and then on the shady one. Period between blossoming of male and female flowers is 5-8 days.

As far as question of blossoming of male generative sphere of protandrous and protogenic *Juglans regia* individuals is concerned, we received the following data. In contrast to coming into the phase of flowering of male generative sphere of protandrous and protogenic individuals, where protandrous individuals came first into the phase of flowering, in the process of blossoming of female generative sphere we ascertained reverse appropriateness. It means that protogenic individuals come first into the phase of flowering, and then protandrous one. By the way mentioned appropriateness was observed even during different climatic factors (temperature, humidity of the air, precipitation). So, in 2010 year female flowers of protogenic individuals came into the phase of blossoming on the 5<sup>th</sup> of May, and protandrous one on the 9<sup>th</sup> of May; in 2011 year properly – the 10<sup>th</sup> of May and 16<sup>th</sup> of May; in 2012 year – the 2<sup>nd</sup> and 7<sup>th</sup> of May (picture 3).

Analysis of climatic factors during the period of flowering of protogenic individuals showed that temperature and humidity of the air in the time of these periods were the following: in 2010 year - +17 °C and 53%; in 2011 year - +14,7 °C and 62%; in 2012 year - +21,5 °C and 47,8%.

As far a process of flowering of protandrous individuals is concerned, in appropriate period temperature and humidity of the air were the following: in 2010 year +14,1 °C and 79.7%; in 2011 year + 11,5 °C and 85%; in 2012 year +17 °C and 63%. So, it follows from the given data that during the years of researches the quickest female generative sphere of protogenic individuals came into the phase of flowering in 2012 year (the 2<sup>nd</sup> of May), and the latest in 2011 year (the 10<sup>th</sup> of May), and concerning protandrous individuals, the quickest was in 2012 year (the 7<sup>th</sup> of May), and the latest was in 2011 year (the 16<sup>th</sup> of May).

Period of blossoming of female flowers lasted from 5 to 8 days depending on weather conditions. After blossom fall male aments dry up and fall, but pollinated female flowers continue to function till the process of seeds and fetus formation. Beginning of mass flowering of male aments of protogenic *Juglans regia* individuals happens after blossoming of female flowers in 3-4 days. Mass blossoming of female flowers of protandrous individuals happens in 4-5 days after blossoming of male one and sometimes even later.



Picture 3 Female flowers of protogenic (a) and protandrous (b) *J. regia* individuals in the period of coming into the phase of blossoming (the 3<sup>rd</sup> of May 2012 year)

## Conclusions

Dichogamy of *Juglans regia* is biologically stipulated natural process that depends on genetic factors and is controlled by climatic conditions, decisive meaning of which belongs to temperature and humidity of the air. Flowering of protandrous and protogenic individuals of Circassian walnut in conditions of Ternopil region happens in different terms, difference between these terms is 7-8 days regardless of climatic factors and lasts averagely for 16 days. Mass blossoming of examined individuals is on the 6<sup>th</sup>-7<sup>th</sup> day. Twenty-four hours rhythm of flowers bloom of *Juglans regia* is daily.

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#### ОСОБЛИВОСТІ БІОЛОГІЇ ЦВІТІННЯ ПРОТАНДРИЧНИХ І ПРОТОГІНІЧНИХ ОСОБИН *JUGLANS REGIA* L. У ЗВ'ЯЗКУ З ДИХОГАМІЄЮ

У статті наведені результати дослідження біології цвітіння *Juglans regia* L. протандричних і протогінічних особин у зв'язку з дихогамією. Проаналізовано особливості цвітіння особин залежно від кліматичних умов (температури та вологості повітря, опадів, освітленості) в умовах Західного Поділля (Тернопільська обл.). Встановлено, що дихогамія в роді *Juglans* L. виникла протягом еволюції рослинного світу як пристосування до перехресного запилення.

*Ключові слова* : дихогамія, протандрія, протерогінія, біологія цвітіння, кліматичні умови, *Juglans regia*

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#### ОСОБЕННОСТИ БИОЛОГИИ ЦВЕТЕНИЯ ПРОТАНДРИЧЕСКИХ И ПРТОГИНИЧЕСКИХ ОСОБЕЙ *JUGLANS REGIA* L. В СВЯЗИ С ДИХОГАМИЕЙ

В статье приведенные результаты исследования биологии цветения *Juglans regia* L. протандрических и протогинических особей в связи с дихогамией. Проанализированы особенности цветения особей в зависимости от климатических условий (температуры и влажности воздуха, осадков, освещенности) в условиях Западного Подолья (Тернопольская обл.). Установлено, что дихогамия в роде *Juglans* L. возникла в течение эволюции растительного мира как приспособления к перекрестному опылению.

*Ключевые слова* дихогамия, протандрия, протерогиния, биология цветения, климатические условия, *Juglans regia*

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