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MORPHOLOGY AND REPRODUCTIVE BIOLOGY OF PERENNIAL BUCKWHEAT *FAGOPYRUMCYMOSUM* MEISSN

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Abstract:

Fagopyrum cymosum Meissn. is a wild species of buckwheat, typically growing in southwest Asia for many years. Despite the versatile use of perennial buckwheat by people, embryological features of this species have not been studied. Meanwhile, the success of the seed reproduction of the species depends on how successfully these processes pass. The data on morphology, seed productivity, and vegetative reproduction of F. cymosum in the territory of European Russia, especially in the case of an attempt to introduce the species, are also of interest. In this study, we wanted to investigate the morphology and individual aspects of the reproductive biology of Fagopyrum cymosum in the Republic of Tatarstan. As a result, a complete botanical characteristic of perennial buckwheat has been given. It turned out that the structure of the perennial buckwheat flower is characterized by high variability. The most common were flowers with the formula $P_5A_8G_{(3)}$ (83,3 %) and $P_5A_9G_{(3)}$ (10,7 %). Perennial buckwheat in the Republic of Tatarstan is pollinated by wild hymenoptera and dipterous insects. The sugariness of perennial buckwheat nectar compared to the selection varieties of common buckwheat is insignificant, averaged 0.03 mg of sugar per flower. Embryological processes in perennial buckwheat proceeded similarly to other species of buckwheat. The number of microsporocytes in the anther lobe averaged 5.5. As disturbances in the development of the male reproductive sphere of the flower, suspended development of sporogenous tissue were revealed, often accompanied by premature destruction of the inner layers of the wall of the anther lobe, as well as a few cases of disorders during meiosis. Disturbances at different stages of the formation of the female gametophyte were detected. Estimated pollen productivity in buckwheat perennial was on average 704 pollen grains per flower. The fertility of pollen was within 87.5-96.8%, depending on the weather conditions. The actual seed productivity of perennial buckwheat varied from 26.7 to 186.0 seeds per plant. As a result of the study, it was concluded that buckwheat perennial can be grown in the Middle Volga region as an annual crop.

Key Words: *Fagopyrumcymosum Meissn., morphology, flower, embryological processes, pollen fertility.*

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1. INTRODUCTION:

Fagopyrumcymosum Meissn. is the most common plant among wild-growing long-term species of buckwheat, growing in southern China [1], as well as in the territory of Bhutan, Nepal and India. The species exists both in diploid and tetraploid forms [2, 3]. It is an allogamous entomophilous species, with such characteristics as heterostyles and self-compatibility [4, 5].

Perennial buckwheat finds quite a wide application in human economic activity. In some areas of its habitat, the species is used as a green vegetable or animal feed [6]. Among the wild-growing species, only *F. cymosum* is used as a medicinal herb, mainly in China [7]. There is evidence that *F. cymosum* may represent a promising source of flavonoid – rutin [8]. Perennial buckwheat is successfully involved in interspecific crossings in order to improve the cultivated species of buckwheat. To date, hybrids of *F. cymosum* with *F. tataricum* (L.) Gaertn., *F. esculentum* Moenchand *F. homotropicum* Ohnishi have been obtained [9].

Despite the versatile use of perennial buckwheat by people, embryological features of this species have not been studied [10]. Meanwhile, the success of the seed reproduction of the species depends on how successfully these processes pass. The data on morphology, seed productivity, and vegetative reproduction of *F. cymosum* in the territory of European Russia, especially in the case of an attempt to introduce the species, are also of interest. In this connection, tasks were set to conduct a complete morphological study of *F. cymosum*, including the study of the course of embryological processes, and also to consider certain aspects of reproductive biology of the species in the conditions of the Republic of Tatarstan.

2. METHODS:

A tetraploid sample of *F. cymosum* K-4231 (the country of origin - India) obtained from the N.I. Vavilov All-Russian Institute of Plant Genetic Resources was used as the research material.

Materials for research were selected in the fields of the Tatar Scientific Research Institute of Agriculture (Laishevsky District of the Republic of Tatarstan, Russia) in the collection nursery in summer 2014-2017. The soil of the site is gray forest, medium loamy. The area of plant nutrition is 30-15 cm. The sowing was carried out in May in warmed soil, the specific dates of sowing varied depending on the weather conditions. Vegetation of plants was interrupted in October under the influence of the first frosts. At the time of the forced termination of vegetation, the plants simultaneously had open flowers, maturing and ripe fruits.×

To assess the quantitative morphological characteristics and seed productivity of plants, 25-35 plants were randomly selected. To study the morphology of the flower, 300 flowers were randomly selected in plants during their mass flowering phase. To study the embryological features of the inflorescence, the buds and fruits were fixed in the Chamberlain solution. They were used to prepare permanent specimens [11, 12]. To determine the sugar content of buckwheat nectar the flushing and Hagedorn-Jensen methods [13] were used. In summer 2016-2017, field research was conducted on the fertility of buckwheat pollen using the iodine method [11]. During the mass flowering phase, the pollen fertility of 50 flowers was studied in 5 fields of view of the microscope. The pollen productivity of the flower was also calculated based on the average number of microsporocytes in the anther lobe [14].

The results of all studies were processed using AGROS software package of statistical and biometrics and genetic analyzes in plant growing and selection [15].

3. RESULTS AND DISCUSSION:

Morphology of *F. cymosum*

The height of perennial buckwheat plants in different years ranged from 176.0-2.8 cm to 182.5-3.6 cm. The shoots are strongly branched from the base, with 13.6-0.7 to 14.5-0.4 branches of the first order on the main shoot. The number of nodes in the upper part of the shoot bearing inflorescences varied from 10.7-0.3 to 14.4-1.1. In the second half of the vegetation in the first year of plant life a powerful rhizome is formed, due to which plants are capable of vegetative reproduction by sarmentation. The next spring of the after planting, the plants did not grow and, therefore, did not overwinter in the conditions of the Republic of Tatarstan.

The leaf of perennial buckwheat is elongated, triangular, with a spear-shaped base and elongated apex. Lower leaves - long-petiolar with 4 pairs of lateral veins, upper - short-petiolar with 3 pairs of lateral veins. Venation - palmately veined. The leaflet of the leaf is pubescent with simple short, soft hair. The leaf is velvety by touch, pubescent with short simple hair along the large veins, wit thicker pubescence on the upper side of the leaf.

Inflorescences in perennial buckwheat represented

branched thyrsusi. The number of thyrsusi on one peduncle varied from 5.1±0.1 to 6.1±0.2. The number of cymes per one thyrsus was on the average 14.0±0.5. For comparison, common buckwheat and Tatar buckwheat had unbranched thyrsusi, and the amount of cymes on the thyrsusi was 7-9 and 4-5 [16], respectively, i.e. inflorescence of perennial buckwheat are much more branched.

The flower is complete, bisexual, asymmetric, pentacyclic, heteromeric. Pedicel, approximately equal in length to flower, is thin, glabrous, with articulation in middle part, curved, white. Faded flowers are easily crumbled when touched. Heterostylism of flowers is characteristic.

The perianth is simple, white, composed of 5 free leaves. Perianth leaves are whole, with pointed top, horizontal, smooth, glabrous, tender. The leaves of the outer circle are noticeably smaller than the leaves of the inner circle, the intermediate leaf is asymmetric. The perianth remains with the developing fetus; after blossoming it dries.

Stamens normally in number of 8, 5 stamens of the outer circle are subopposite to tepals, 3 stamens of the inner circle are subopposite to the edges of the ovary. Stamens are free, straight or slightly curved, equal in length. They are normally fertile, contain pollen ready for pollination. Stamina filaments are hairy, thin, long, glabrous, smooth. The anthers are fixed immovably in the middle along the back, apical, shorter than the stamen filament, oval in shape, smooth, glabrous, free, opening with a longitudinal slit.

Pistil of 3 fused carpels. Superior, trihedral, smooth, glabrous, single-cavity ovary with one basal orthotropic ovule. Stylodia are filiform, free, glabrous, remaining on the ovary, but fading and losing their original shape. Stigmas are apical, small, simple, rounded, with papillae. Gynecium is lysicarpic.

The flower of perennial buckwheat proved to be sufficiently variable, as well as other types of buckwheat previously studied [17]. Flowers with the formula $P_5A_8G_{(3)}$ were noted in 83.3% of cases. Variant $P_5A_9G_{(3)}$ was found with a frequency of 10.7%. In the overwhelming majority of cases, such flowers had an additional stamen in the inner circle of the androecium. With a frequency of 1.5% the variant $P_5A_7G_{(3)}$ was observed, characterized by the fall of one of the inner circle stamens. These results confirm the model of bipolar marking of flowers proposed for the family *Polygonaceae* [18]. In addition to the above variants of the structure, flowers with a flat dihedral gynecium (1.0%) and flowers with six tepals (1.0%) were found. Several more variants of the structure of the flower were recorded as single cases.

The fruit of perennial buckwheat is a single-seeded winged nut. The surface of the fruit is bare, smooth. The shape of the nut is tetrahedral, the shape of the face is rhombic. Color of fruit is brown, uniform.

Anthecology and nectar bearing capacity

Observations conducted at the end of July in the morning hours at an air temperature of 25°C showed that the perennial buckwheat flowers opened at 7 am for about half an hour. At the end of the next hour, the opened stamens of the inner circle could be observed in the flowers, the process of opening of the outer circle stamens lasted nearly one hour more.

The flowers closed at 22.00-22.30 in total darkness, i.e. remained open for about 16 hours. The flowers that opened the day before did not open the next day. The flowers of perennial buckwheat have nectaries in the form of glandular tubercles of yellow flower. They are located around the base of the ovary and are confined to stamens. Flowers emit a faint fragrance. They were eagerly visited by wild hymenoptera and diptera. Honey bees flying to a number of flowering cultivated and wild-growing mead, passed perennial buckwheat by.

In the first decade of August 2016, samples for nectar bearing capacity of flowers were taken in optimal conditions for nectar selection. At the time of sampling (at 7 o'clock in the morning), the air temperature was 25°C, at night it was raining with a thunderstorm. There were especially many pollinators on plants. The evaluation showed that the content of sugars in the perennial buckwheat nectar per flower is 0.03 mg. For comparison, the sugar content of nectar of zoned and promising buckwheat varieties has fluctuated in our studies in 2013-2015 from 0.08 to 0.26 mg of sugar per flower [19].

Embryology, pollen fertility and seed yield

Anthers of perennial buckwheat are tetrasporangiate. The wall of the anther lobe develops as monocotyle, the formed wall consists of four layers of cells: epidermis, endothecium, middle layer and tapetum. Cells of sporogenous tissue are located in the anther lobe in one row. The number of microsporocytes in the anther lobe varied from 4 to 8 pieces and averaged 5.5-0.12. Microspores are formed by the simultaneous type. Mature pollen grains are three-celled.

Quite often there were anthers in the sections where the development of sporogenous tissue occurred, and it was often accompanied by premature destruction of the inner layers of the wall of the anther lobe. A few cases of defects during meiosis in the form of pentad microspores, as well as tetrads with collapsing microspores, have been identified.
Estimated pollen bearing capacity in perennial buckwheat was about 704 pollen grains per flower. In the process of assessing the fertility of pollen, it was noted that in many flowers mature pollen varied in size. Small pollen grains often turned out to be sterile, evidently formed as a result of a disturbed assortment.

Pollen fertility was assessed during the mass flowering phase in 2016-2017 (Table 1). The weather conditions of buckwheat vegetation in these years were different, so the beginning of the phenological phase also differed greatly. The conditions of pollen formation were judged from the value of the Selyaninov hydrothermal coefficient [20]. Weather conditions during the formation of pollen affected its fertility: drought resulted in the lower indicator.

Table 1 – Pollen fertility in perennial buckwheat depending on weather conditions during the formation of pollen

Determining pollen fertility date	Selyaninov hydrothermal coefficient	Pollen fertility, %
July 28, 2016	0.06 (severe drought)	87.5 - 1.8
September 2, 2017	1.14 (optimum hydration)	96.8 - 0.6

A perennial buckwheat ovule is orthotropic, bitegmic, crassinucellar. After the meiosis of the megasporocyte, a linear or T-shaped tetrad of megaspores is formed. There were no violations in meiosis. Embryonic Polygonum-type sac. The polar nuclei merged before fertilization.

The female reproductive sphere of the flower had developmental disorders at the stage of the dual- and eight-nuclei embryo sac found.

In the central part of the long-acting buckwheat fruit there was a large embryo with folded cotyledons, surrounded from all sides by endosperm cells.

The real seed yield of perennial buckwheat in different years varied from 26.7±3.8 to 186.0±14.9 seeds per plant. Observations over the fruit maturation, as well as embryological studies have shown that both perennial buckwheat and common buckwheat [20] have a significant amount of the fetuses being aborted at different stages of development.

The study showed that the embryological processes in *F. cymosum* are similar to those in the cultivated species of buckwheat *F. esculentum* and *F. tataricum*.

Perennial buckwheat in the Middle Volga region is easily renewed by self-seeding.

4. SUMMARY

1. A comprehensive botanical characteristics of perennial buckwheat *Fagopyrum cymosum* Meissn. of the Middle Volga region is provided.
2. The structure of the perennial buckwheat flower is characterized by high variability. The most common are flowers found with the formula $P_5A_8G_{(3)}$ (83.3 %) and $P_5A_9G_{(3)}$ (10.7 %). The latter are characterized by the presence of an additional stamen in the inner circle of the androecium.
3. Perennial buckwheat in the Republic of Tatarstan is pollinated by wild hymenoptera and Diptera. The sugariness of perennial buckwheat nectar is negligible, averaging 0.03 mg per flower.
4. Anthers of perennial buckwheat have four anther lobes. The wall of sporangia developed as a monocotyle, the formed wall consisted of four layers of cells: epidermis, endothecium, middle layer and tapetum. The number of microsporocytes in the anther lobe averaged 5.5-0.12. Microspores were formed according to the simultaneous type. Mature pollen grains are three-celled. As the development defects of the male reproductive sphere of the flower, suspended development of sporogenous tissue were revealed, often accompanied by premature destruction of the inner layers of the wall of the anther lobe, as well as a few cases of disturbances during meiosis. The ovule is orthotrophic, bitegmic, crassinucellar. Megaspore tetrad is linear or T-shaped. An embryo sac is of polygonum-type. Abnormalities were found at different stages of formation of the female gametophyte. A large embryo with folded cotyledons, surrounded from all sides by endosperm cells, was found in fruits.
5. Estimated pollen bearing capacity in perennial buckwheat was about 704 pollen grains per flower. The fertility of pollen was within 87.5-96.8%, depending on the weather conditions.
6. The real seed yield of perennial buckwheat varied

in the years of research from 26.7 to 186.0 seeds per plant.

5. CONCLUSION:

The study showed that perennial buckwheat *F. cymosum* can grow in the conditions of the Middle Volga region as an annual crop. Its renewal is possible by self-seeding.

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REFERENCES:

[1] Y. Tang, M.-Q. Ding, Y.-X. Tang, Y.-M. Wu, J.-R. Shao, M.-L. Zhou, «Germplasm Resources of Buckwheat in China», *Molecular Breeding and Nutritional Aspects of Buckwheat*, Elsevier Inc., p. 13-20, 2016.

[2] O. Ohnishi «Distribution and classification of wild buckwheat species 1. Cymosum group. Review», *Fagopyrum*, vol. 27, p. 1-8, 2010.

[3] K. Yamane, O. Ohnishi, «Morphological variation and differentiation between diploid and tetraploid cytotypes of *Fagopyrum cymosum»,Fagopyrum*, vol. 20, p. 17-25, 2003.

[4] A.S. Krotov, V.N. Lysov, I.I. Sokolov, "Buckwheat - *Fagopyrum* Mill.", Cultural Flora of the USSR, Vol.3, L.: Kolos, 1975, p. 3-118.

[5] N.V. Fesenko, N.N. Fesenko, O.I. Romanova, "Gene pool and selection of cereals. Buckwheat", St.P.: SSC RF VIR, 2006, p. 196.

[6] C. Campbell, «Buckwheat crop improvement», *Fagopyrum*, vol.20, p. 1-6, 2003.

[7] O. Ohnishi, «Distribution of wild species and perspective for their utilization», *Fagopyrum*, vol. 30, p. 9-14, 2013.

[8] A.G. Klykov, L.M. Moiseenko, P.G. Gorovoi, "Seasonal dynamics of routine content and productivity of overground phytomass in three species of *Fagopyrum* Mill., cultivated in Primorsky Krai", Vegetativnye resursy, Vol.3, p. 77-82, 2003.

[9] G. Suvorova, «Interspecific Crosses in Buckwheat Breeding», *Molecular Breeding and Nutritional Aspects of Buckwheat*, Elsevier Inc., p. 87-98, 2016.

[10] M.P. Solntseva, «Family *Polygonaceae»Comparative embryology of flowering plants. Phytolaccaceae – Thymelaeaceae*. L: V.L. Komarov Bot. Institute, 1983, p. 53-58.

[11] Pausheva Z.P. Practical course on plant cytology. - M.: Agropromizdat, 1988. p. 271.

[12] Barykina R.P. Handbook of botanical microtechnology. Bases and methods. - M.: Moscow State University, 2004. p. 312.

[13] Methodological guidelines for assessing the nectar bearing capacity of important honey plants, Rybnoe: Research Institute of Apiculture, 1984, p. 22.

[14] L.R. Kadyrova, R.R. Muchametshshina, «Pollen Productivity and Pollen Fertility Rate by Representatives of Family *Fagopyrum*Mill.», *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, № 6(6). p. 1695-1702, 2015.

[15] AGROS software package of statistical and biometrics and genetic analyzes in plant growing and selection. Version 2.08. Tver, 1999.

[16] K.O. Potapov, L.R. Kadyrova, R.R. Mukhametshina, «Embryological features and seed productivity of tartary buckwheat», *J. Fundam. Appl. Sci.,* 9(1S), p. 1462-1471, 2017.

[17] L.R. Kadyrova, «Floral Polymorfism in *Fagopyrum*Mill.», *Research Journal of Pharmaceutical, Biological and Chemical Sciences*,. № 6(6), p. 1404-1411, 2015.

[18]Chub V.V., Iurtsev O.V. Mathematical modeling of flower formation in the members of the family *Polygonaceae* // Bot. Journal. 2007. V.92. No.1. p. 114-134.

[19] K.O. Potapov, L.R. Kadyrova, G.N. Galiullina, F.Z. Kadyrova, A.T. Khusnutdinova, I.Yu. Nikiforova, «Morphological features and economic value of buckwheat varieties with physiological determination of growth», *Journal of Pharmacy Research*, vol, 11, Issue 10, p. 1252-1256, 2017.

[20] Agricultural encyclopaedic dictionary, M.: Soviet encyclopaedia, 1989, 656 p.