Seabuckthorn (*Hippophae* L.)*: A multipurpose Wonder Plant*. Vol. 1 (V. Singh et al., Eds., 2003, India), p. 99-104

Biology of Flowering, Pollination and Fertilization in Seabuckthorn

V.A. Fefelov and V.V. Selekhov

Nizhny Novgorod Agricultural Academy, Gagrin Avenue 97 Nizhny Novgorod 603107 Russia (E-mail: fefelov@osi.nnov.ru)

ABSTRACT

Flowering in seabuckthorn {Hippophae rhamnoides L.) occurs, as a rule, during first decade of May, along with leaf expansion. Under dry warm weather, the flowering lasts for 3-4 days, whereas, it proceeds for 6-12 days in more cool and humid seasons. In southern Ural, male plants begin flowering 2 days later than female plants. Decrease of pollen expenses is also achieved by the mechanism of pollen ejection. When the flower has opened, there occurs sharp alteration of air humidity inside it, anthers burst and pollen spills. Therefore, pollen is mostly located not in anthers but at the bottom of the flower. Such a state allows safe pollination even in short-term improving during the prolonged bad weather. It is one of the main reasons of stable seabuckthorn productivity. It was observed that plants with big buds appeared to be better pollinators, because they form many good flowers and, accordingly, are more pollen producing. In the bud of such plants, up to 25 flowers are found, while usually a male bud contains 12-15 flowers on the average. Pollen grains fly out individually, not in groups. Female seabuckthorn flower can receive pollen during 7 days. The germination of the pollen grains occurs in 3-4 hours, and fertilization in 5-10 days after pollination. Many investigators have established experimentally that pollinator influences the weight and biochemistry of fruits, and weight of the hybrid seeds.

Key words: Seabuckthorn, biology of flowering, pollination, fertilization and metaxenia.

FLOWERING

The beginning and duration of seabuckthorn flowering much depend on the weather conditions. Under dry warm weather, the flowering lasts for 3-4 days, whereas, it proceeds for 6-12 days in more cool and humid seasons. Age of the plants also influences the process, as young species have the phenophase some days shorter than senile plants of the same variety. The flowering of different seabuckthorn forms in Moscow region varies to 3-5 days. Trofimov (1976) has observed the earliest time of the blossoming in Altay (Siberian climatype) and Leningrad, spontaneous hybrid population of Baltic and Katun forms. Forms from the southern coast of the Baltic sea would linger for 4 days. According to Ilyina (1983), intervarietal differences in the beginning of flowering are insignificant and make 2 days. We ourselves observed no authentic differences in terms and duration of the process between 13 seabuckthorn populations, represented in the experiment. The small differences happened in every population for flowering as an independent character (Fefelov, 1985).

There are the studies about earlier male anthesis (Mochalov, 1974; Salatova, 1974; Trofimov, 1976; Filatov, 1979). As reported by Ilyina (1983), in southern Ural, males begin flowering 2 days later than female plants. Having got rather representative plants, we did not mark any deviation among male and female samples on the phenophase. Apparently, these differences are non-sexual and depend only on individual features of plants.

Seabuckthorn flowering occurs, as a rule, during first decade of May, along with leaf expansion. Time of the flowering depends on the thermal mode of the preceding period. Faustov and Ermakov (1978) in Moscow region, found the sum of active temperatures of 192-204°C is necessary for the beginning of flowering and 192-312°C for the mass blossoming. Under the conditions of Southern Ural, the anthesis begins at 157-205°C (Ilyina, 1983). In a plain area of Altay region, seabuckthorn needs 192-318°C for it (Kalinina and Panteleeva, 1978). According to Salatova (1974), the decrease of temperature to 9°C does not cease the flowering. In rainy weather, due to high temperature lowering, male flowers don’t open, and the blossoming lasts for a week. In case of warming during prolonged cold spring, the flowering finishes within 1 -2 days.

Flowers on the inflorescence axis open in an acropetal direction non-simultaneously and usually in days. According to Ilyina (1983), in male inflorescence, lower and middle flowers are first- openers, and same are the basal and middle buds of an annual shoot. In female plants, the similar regularity is observed only within the limits of inflorescence.

POLLINATION

Seabuckthorn, like other wind-pollinated plants, produces a heap of pollen. However, anemophilia is known to be the chaotic and ineffective mechanism of pollen distribution. That’s why anemophilous plants developed various compensatory adaptations and mechanisms for greater effectiveness of pollination (Faegri et al, 1971; Procter and Yeo, 1973). Seabuckthorn is adapted to it through structural reorganization of the flowers and pollen. Evolution of the flowers took place in three directions:

a) Reduction of unusual parts of flowers by means of minimization of their elements;

b) Formation of various adaptations for pollen ejection and catching;

c) Development of regulatory mechanisms of pollen ejection.

In staminal flowers, such mechanisms are the mutual disposition of calyx lobes and stamens. The formers being closed by apexes make goring with lateral openings, which promote pollen blowing out. Besides such disposition of perianth lobes protects pollen against dew and rain. Decrease of pollen expenses is also achieved by the mechanism of pollen ejection. When the flower has opened, there occurs sharp alteration of air humidity inside it, anthers burst and pollen spills. Therefore, pollen is mostly located not in anthers but at the bottom of the flower. Such a state allows safe pollination even in short-term improving during the prolonged bad weather. It is one of the main reasons of stable seabuckthorn productivity. We observed that plants with big buds appeared to be better pollinators, because they form many good flowers and, accordingly, is more pollen producing. In the bud of such plants, up to 25 flowers are found, while usually a male bud contains 12-15 flowers on the average. In our hybrid fund, there are the plants having greater number of flowers in a bud through formation of so called accessory buds (Fig. 1), originated from several separated lower flowers (Fefelov et al, 1997). Total number of flowers, amounts to 29-30 pcs.

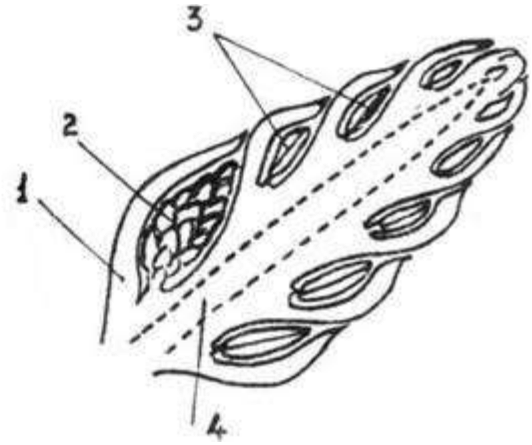

Fig. 1. Accessory flower bud under the lower scale of common male bud
(1-bud scale, 2-accessory bud, 3-anthers, 4-bud axis)

Potential efficiency of wind-pollination is also advanced by other evolutionary mechanisms. During male anthesis, there is leaf growth only in apical part of the buds, cataphyllary leaves don't increase and don't prevent pollen dispersion. On the contrary, in the female buds, they expand till flower opening. During blossoming, leaf plate alternates the direction of air stream that favors the pollination. Stigma raised above perianth promotes it either. The stigma grows till fertilization and gradually transforms into long spiral. Therefore, it's surface increases and the probability of pollination progresses.

In anemophilous plants, the evolution of the pollen structure went on to the development of its aerodynamic properties. Like in the other wind-pollinating plants, seabuckthorn pollen possess smooth dry surface. Pollen grains fly out individually, not in groups. Flying ability of pollen depends also on the size and weight of the pollen grains. Usually diameter of pollen in angiosperms ranges from 10 to 25 microns (Frankel and Galun, 1977). Seabuckthorn has pollen varying from 26 to 44 microns (Fefelov et al, 1998). The preservation of the pollen viability under natural conditions during the certain period of time is the essential factor for the successful sexual process. In this period, called as period of mobile phase of dispersion, the pollen undergoes unfavorable influences like air temperature and humidity. The pollen reduces its fertility fast, when intensive warming in April-May causes early and short flowering. Under optimal conditions, viability of the pollen increases.

Cross-pollination occurs only at simultaneous flowering of the pollen donor and recipient. In seabuckthorn, the coordination of dusting time and a period of receptive stigmas depends on the presence of flower populations, potentially capable to interbreeding. And the elongation of the period of effective flowering has the multilevel insurance. The duration of anthesis attains through non-simultaneous flower opening on inflorescence, annual shoot and the whole plant. Besides, the ecological and genetic diversities extend the period within a population.

Among the selected males, we observed plants with three types of male anthesis (Fefelov et al, 1999):

a) Early short flowering;

b) Continuous prolonged flowering

c) Late flowering.

In the first group, about 95% of flowers open during 1-2 days. Flowers of the second group open little by little from the base of annual shoot to its apex, during 6-7 days. Plants of the third type begin to dust at the end of flowering of the second group. Weather conditions may reduce the differences.

FERTILIZATION

Female seabuckthorn flower can receive pollen during 7 days (Sokolova, 1985). Unpollinated stigma grows transforming to ribbon-like spiral of 7-10 mm. After pollination, the growth ceases. Without pollination, hypanthium does not expand and drops down together with the flower. Trofimov (1976) noted that by anther burst, unicellate pollen grain turns to bi- and tricellate one. The generative cell division starts in pollen grain and comes to finish in the pollen tube. The germination of the pollen grains occurs in 3-4 hours, and fertilization in 5-10 days after pollination. The interaction between pollen grain and stigma surface induces processes, which have not been quite studied. It remains unknown what a way pollen tube finds nucellus. Jensen (1974) showed that from that stage to the double fertilization, the process, probably, goes equal in all the angiosperms.

METAXENIA

In the literature, there is an old dispute on how the male genotype may influence the somatic cells of the fruit. It is well known that only germ and endosperm have a hybrid nature, the other parts of the fruit originates from mother cells. At the same time, a number of the scientists describe the phenomenon of metaxenia, when some parameters of the fruits (coloring, weight, biochemical composition) vary depending on the pollinator. In seabuckthorn for the first time, this phenomenon was noticed by Eliseev (1976). Later on he (Eliseev, 1984) and other investigators (Buglova, 1981; Ilyina, 1983; Potapov et al., 1986) established experimentally that pollinator influence the weight and biochemistry of fruits, and weight of the hybrid seeds. We investigated the effect of several contrast pollinators on two cultivars-recipients distinguishing on the morphological and biological features. The researches have shown that the influence on fruit setting is rather essential and statistically authentic, even under the condition of significant surplus of pollen (Table 1). These differences and regularities emain under varying weather conditions. Weather affects only the degree of expression. Thus, we may affirmatively speak about the specificity of pollinator's influence on the female plants and about possible presence of the universal pollinators, adapted to many female cultivars.

Studies on the fruit's biochemical composition haven't confirmed Eliseev's opinion (1984) about the effect of pollinators on the synthesis of some substances in the hypanthium i.e., modification in the contents of bioactive substances, fat and the structure of the latter. As far as we can judge, pollinators have an indirect influence on the quantitative and qualitative parameters of the fruits. Different attractive forces of the seeds, duration of period of their development before separation from the mother plant etc. stipulate this influence. Therefore, even within the limits of one cross, number of biochemical parameters is observed varying, depending on the weather conditions.

Pollinator	***1997***		***1999***	
	Cultivar-recipient		***Cultivar-recipient***	
	38/90	***21/90***	***38/90***	***21/90***
Free pollination	4.5	4.9	2.7	-
7/87	2.2	3.0	1.9	3.1
15/89	4.9	4.0	2.9	-
1/91	4.9	5.5	2.5	-
3/91	5.0	6.5	3.4	3.7
AD_{05}	0.72	0.76	0.33	-

REFERENCES

1. Buglova, T.L. 1981. Evaluation of the initial seabuckthorn forms for breeding and inheriting of main economic and biological properties: Abstract of Candidate Thesis. Leningrad

2. Eliseev, I.P. 1976. Metaxenia (xenia of the second order) in seabuckthorn In: Fruit and Berry Cultures: Proceedings of Gorky Agricultural Institute 100: 3-9. Gorky.

3. Eliseev, I.P. 1984. Some physiologic-biochemical and genetic aspects of seabuckthorn introduction and selection. In: Physiology, Electrophysiology and Biochemistry of Agricultural Plants: Proceedings of Gorky Agricultural Institute, p. 3-26. Gorky.

4. Faeqri, K., Pijl, L. & Yan, D. 1971. The Principles of Pollination Ecology (2nd ed.). Oxford.

5. Faustov, V.V. & Ermakov, B.S. 1978. Biological features of seabuckthorn growth and fruit bearing In: Seabuckthorn, p. 33-46. Moscow.

6. Fefelov, V.A. 1985. Development of seabuckthorn of various origin and its seasonal rhythm under cultivation In: Biological Aspects of Introduction. Selection and Agrotechnics of Seabuckthorn: Proceedings of Gorky Agricultural Institute, p. 64-71. Gorky.

7. Fefelov, V.A., Selekhov, V.V., Korovina, M.A.& Kuznetsova, T.N. 1998. The materials for making selection program for male plants-pollinators of Hippophae rhamnoides In: Materials of the 3d International Symposium on Seabuckthorn, p. 32-35, Ulan-Ude, 24-29 Aug., Novosibirsk, Russia.

8. Fefelov, V.A., Korovina, M.A. & Selekhov, V.V. 1997. The estimation of some new seabuckthorn cultivars for winter resistance. In: Agricultural Systems for Non-Blacksoil Zone of Russian Federation and Their Perfecting. Theses of the Reports. N. Novgorod

9. Fefelov, V.A., Selekhov, V.V., Korovina, M.A., Kuznetsova, T.N. & Fefelova, N.N. 1999. Results of seabuckthorn male morphs-pollinators selection In: Proceedings of III International Symposium on New and Non-Traditional Plants and Perspectives of Their Use, p. 450-452. Moscow.

10. Filatov, 1.1. 1979. Forest characteristics of seabuckthorn bushes of the Southeast of Kazakhstan: Abstract of Candidate Thesis, 20 p. Alma-Ata.

11. Frankel, R. & Galun, E. 1977. Pollination Mechanisms, Reproduction and Plant Breeding. Berlin Heidelberg, New York.

12. Hina, N.A. 1983. Biological peculiarities and commercial value of some cultivars and forms of seabuckthorn in conditions of Southern Ural. Abstract of Thesis^ 21 p. Leningrad.

13. Jensen, W.A. 1974. Reproduction in flowering plants. In: Dynamic Aspects of Plant Ultrastructure (Robards, A.W. (Ed.), p. 481-503, London Mcgraw-Hill.

14. Kalinina, I.P. & Panteleeva, E.I. 1978. Seabuckthorn selection in Altay. In: Seabuckthorn, p. 56-80. Moscow.

15. Mochalov, V.V. 1974. Introduction of seabuckthorn in Novosibirsk region. In: Proceedings of Novosibirsk Fruit and Berry Experimental Station, Iss. 1. Novosibirsk, p. 99-108.

16. Potapov, S.P., Borodachev, M.N., Starikova, A.Kh. 1980. Influence of pollinators on weight of seabuckthorn fruits and seeds. In: Report: Condition and Perspectives of Seabuckthorn Cultivation in Non-Blacksoil Zone of Russia, Moscow.

17. Procter, M. & Yeo, P. 1973. The Pollination of Flowers. London, Collins.

18 Salatova, N.G. 1974. Seabuckthorn biology and fundamentals of economy In: Seabuckthorn in Siberia, p. 6-43, Novosibirsk.

19 Sokolova, E.P. 1985. Period of seabuckthorn flower susceptibility to pollination In: Problems of Horticultural Intensification in Central-Blacksoil Region of Russia. In: Proceedings of Voronezh Agricultural Institute, p. 178-185, Voronezh.

20 Trofimov, T.T. 1976. Seabuckthorn Under Cultivation. Moscow. 159 p.