Environmental aspects of cranberry cultivation in the south of the Khabarovsk Territory

V A Kuptsova¹²* and T A Kopoteva¹

¹ Far Eastern Agricultural Research Institute of the Far Eastern Branch of the Russian Academy of Sciences (FEARI FEB RAS), 13, Klubnaya St., Vostochnoe, Khabarovsk Territory, 680521, Russia
² Institute of Water and Ecology Problems of the Far Eastern Branch of the Russian Academy of Sciences (IWEP FEB RAS), 56, Dikopol'tsev St., Khabarovsk, 680000, Russia
*E-mail: victoria@ivep.as.khb.ru

Abstract. The article represents the results of the introduction of American varieties of Vaccinium macrocarpon in the Khabarovsk Territory. Cranberry is of great value in human nutrition due to its high nutritional significance and unique medicinal value. The experience of plantation cultivation of cranberry in the United States, Canada, Germany, Sweden, Poland, and Belarus proves the high efficiency of its cultivation: yields on plantations are tens or even hundreds of times higher than in natural brushwoods. Early, medium and medium-late varieties with high consumer properties are the most suitable for cultivation in the South of the Khabarovsk Territory. The advantages of cranberry cultivation in the region are the wide distribution of peat-like and peaty soils, suitable natural and climatic conditions, experimental confirmation of the possibility to obtain high yields of berries, and a high economic effect. Cranberry cultivation can also help reduce the anthropogenic load on the natural berry fields of the region. The paper provides data on the survivability, length of shoots growth, and yield of these varieties.

1. Introduction
Cranberry is a valuable bog plant, the berries of which have high nutritional and medicinal properties and are in unlimited demand, both in the domestic and global markets.

In the Khabarovsk Territory, there are no more than 140 thousand ha of fruit-bearing cranberry mires, and the mires themselves are very scattered and have small areas [1]. In addition, research data on the dynamics of wild cranberry yield in the Amur River region showed that in this region, as well as in other regions, the yield factor is very unstable and largely determined by the weather conditions of the vegetation period. For example, in the berry fields of the Gur River basin and the Nanaysky District, the yield of wild cranberry in different years ranged from 70 to 428 kg/ha [2].

At the same time, the stocks of wild cranberry in the Amur River region with the same area of bogs are significantly lower than in the European North of Russia, which is probably due to the phytocoenotic conditions of its growth in the Amur River bogs [2]. Compared with European bogs, the vegetation structure of the Amur River bogs has a high share of psychrophilic sub-shrubs (Chamaedaphne calyculata (L.) Moench., Ledum palustre L., Andromeda polifolia L.) and their productivity during the vegetation period is significantly higher [3]. The values of the cranberry productive cover on mesotrophic sphagnum bogs of the Amur River region range from 5-15%. Taking
into account that cranberry is a patient species and in the natural brush woods of bogs is subject to oppression and displacement by other sub-shrubs, the large shrubbing of the Amur region bogs may be a factor that restricts its distribution and productivity in the region greatly.

Along with the above-mentioned facts, increasing economic activity leads to a reduction in the area of natural berry fields. Almost every year in the South of the Far East, forest fires lead to the burning of huge areas of not only forests but also other natural ecosystems, including mires [4].

All these facts lead to a significant reduction in the region’s natural cranberry fields, which are the most attractive object of collection for urban and rural populations, both for personal consumption and for sale [2]. In these conditions, the industrial cultivation of cranberry has not only commercial value but also reduces the recreational load on natural ecosystems.

2. Materials and methods
A study into the feasibility of growing high-quality cranberry in the South of the Khabarovsk Territory was launched in 2000 on the site of Bichevskoye peat bog [5] and continued in 2018-2020 based on Far Eastern Agricultural Research Institute (FEARI)[6]. For planting, cuttings and nurslings of American varieties of bog cranberry were used: Ben Lear, Stevens, McFarlin, and Pilgrim. The so-called dry growing method was used for plantations establishment, which did not require the creation of a complex and expensive basin system. The irrigation regime, especially in the first month after planting, was about 10 l/m² per day. Later, the irrigation varied depending on the temperature and humidity of the air, taking into account precipitation, and, thus, was close to optimal – about 100 mm per week. After planting, to improve the thermal and water conditions, the site was sanded with average-grained sand in a layer of 2-4 cm.

3. Results and discussion
Unlike the wild-growing Vaccinium oxycoccos L. and Vaccinium microcarpum (Turcz. ex Rupr.) Schmalh. in the South of the Khabarovsk Territory, the North American species Vaccinium macrocarpon Aiton is characterized by a high demand for heat and the length of the vegetation period. Thus, for the ripening of berries of early-ripening varieties of Vaccinium macrocarpon during the vegetation period, the sum of positive temperatures of about 2,400 °C is required, and late-ripening ones – 2,500 °C or higher. The average duration of the period from the beginning of vegetation to full ripening of berries should be 150 and 167 days, respectively [7].

The natural conditions of the southern part of the Khabarovsk Territory are similar to those of the States of North America where it is mainly grown (the States of Oregon, Wisconsin, and Massachusetts). It concerns, first of all, the pattern of heat and moisture distribution in the warm period. In the southern part of the Khabarovsk Territory, the amounts of active temperatures range from 2,400-2,600 °C, and the vegetation period of 200 days is sufficient for growing high-quality cranberry. The average duration of the frost-free period is 159 days according to the Khabarovsk weather station and 132 days according to the Bichevskaya one. The average annual precipitation is 695 mm [8]. The number of days in winter when temperatures persist below 20 °C is about 46 on average. During this period, the American large-fruited cranberry requires a cover, since, at temperatures below -20 °C, it can freeze fruit buds and the ends of vegetative shoots. According to the authors’ data [5, 6], the mid-ripening varieties Ben Lear and Stevens were the most resistant to frost damage, which can be explained by the sufficient length of the vegetation period to complete the stiffening of shoots and prepare plants for winter. Frost damages of generative shoots are reduced significantly after mulching the plantation with a layer of sand or peat.

Cranberry is grown on peaty or peat-like soils with a pH of the soil solution from 3.5 to 5.5. This type of soil is widely distributed in the South of the Far East. Only on the low-lying surfaces of the Khabarovsk Territory, they occupy up to 80% of the area or approximately 36 thousand km² of mires and waterlogged lands in the Khabarovsk Territory [9]. For other crops, this type of soil is not suitable without significant costs for liming and applying large doses of mineral fertilizers. Cranberry does not require liming of the soil and is not strict in mineral nutrition compared to traditional crops.

In addition, for the creation of a cranberry plantation, not only sphagnum bogs of the upper and transitional types are suitable, but also drained cutover peatlands (peat quarries) that have some
peat that has not been cutover. Recultivation of such lands has great environmental importance; it is difficult due to the high groundwater level, periodic flooding, and low fertility, and requires large investments. However, when growing cranberry and other berry heath sub-shrubs on cutover bogs, a significant environmental effect was noted – the fire frequency of reclaimed peat-bog soils is reduced [10, 11].

The experience of the United States, Canada, Germany, Sweden, Poland, Belarus, and many other countries proves the high efficiency of berry fields cultivation: yields on plantations are tens or even hundreds of times higher than in natural brush woods [12, 13]. Plantation cultivation of large-fruited cranberry (*Vaccinium macrocarpon* Aiton) has a long tradition in North America and is a profitable branch of agriculture.

In the European part of Russia, the cost of organizing a cranberry plantation is about 300-400 rubles/m² (www.pitekbio.ru). Being cultivated, it begins to bear fruit in the 3-4 year already. Such a high-yielding and low-cost crop as cranberry pays off for the seventh or eighth year after planting. According to specialists of the Institute of Forest (Belarus), each hectare of cranberry plantation can yield a profit of 3-5 thousand US dollars. Such plantations can be operated for more than 100 years [13].

According to the authors’ observations, rooting of cranberry cuttings takes about 2-3 weeks on average, and the best results are shown by cuttings of 9-12 cm long since the development of the root system is directly dependent on the length of the cuttings [6]. The greatest growth potential is recorded in American varieties, which is an important sign of its comfortable state and the possibility of forming a continuous cover. Regular irrigation in protected ground conditions has a positive effect on the growth of cranberry shoots (table 1).

| Varieties/wild forms of cranberry | Growth length of the shoots (cm) | M±tm* | min | max |
|----------------------------------|----------------------------------|-------|-----|-----|
| Ben Lear peatland near Bichevaya settlement [5] | 11±2 | 0.5 | 60.4 |
| Pilgrim | 11±2 | 0.5 | 131.8 |
| McFarlin | 58±6 | 4.9 | 192.0 |
| Stevens | 45±7 | 3.0 | 151.0 |
| *Vaccinium oxycoccos* | 7±1 | 0.3 | 79.5 |
| control in wild populations [5] | | | |
| *Vaccinium oxycoccos* under coverage on the base of the FEARI [6] | 11±0.4 | 1.1 | 44.6 |
| Ben Lear | 65±8 | 25 | 90 |
| Pilgrim | 51±8 | 21 | 83 |
| McFarlin | 46±3 | 26 | 74 |
| Stevens | 59±4 | 32 | 95.0 |

*M±tm – where M – mean annual increment, m – random error;* 
*t – validation test on significance level of 95%*

As noted above, in wild populations, cranberry fructing is not very regular and varies over the years greatly. On the Bichevskiy wetland, the yield of berries in 2003 was 6.9±1.07 g/m² with an average berry weight of 0.57 g, and in 2004 – 57.2±1.3 g/m² and 0.63 g respectively. In contrast to wild forms, high-quality cranberry bears fruit regularly and exceed the yield of wild populations by 10-100 times, which is due not so much responsiveness to growing conditions, but mainly to the yield potential of the variety (table 2).
Table 2. Productivity of cranberry varieties and wild forms [5].

| Variety/wild forms of cranberry | Productivity (g/m²) | Mass of 100 berries (g) |
|--------------------------------|---------------------|------------------------|
| Ben Lear³ | 1054 | 202.3 |
| Stevens³ | 1700 | 187.0 |
| wild populations of *Oxyccoccus quadripetalus*⁵⁶ | | |
| bog near Slavanka settlement | 19.39 | 55.0 |
| bog of the Gur river basin | 17.54 | 56.0 |
| bog near Bichevaya settlement | 6.92 | 57.2 |

³ measured in 2003
⁵⁶ measured in 2000

As the results of the authors’ research have shown, in the southern part of the Khabarovsky Territory, it is advisable to grow early (Early Black, Franklin, Crowley, and Wilcox), medium, and medium-late (Ben Lear, Stevens) varieties of cranberry. Late varieties (McFarlin, Pilgrim) in some years with low amounts of active temperatures can ripen only with the use of covering materials such as “Agrotex”. Perhaps the climatic conditions of the Primorye Territory will be optimal for the growth and sustainable fruiting of late varieties of American cranberry.

4. Conclusion

Thus, the plantation cultivation of cranberry has prospects for further development in the South of the Khabarovsky Territory. The most suitable are early, medium, and medium-late varieties of American large-fruited cranberry with high consumer properties. The advantages of such production are the wide distribution of peat soils in the South of the region, suitable natural and climatic conditions, experimental confirmation of the possibility to obtain high yields of berries, and a high economic effect.

Cranberry cultivation can also help reduce the anthropogenic load on the natural berry fields of the region. For growing cranberry, cutover peatlands abandoned after peat extraction and are a source of carbon dioxide emissions into the atmosphere, and fires can be used. Maintaining a favorable hydrological regime for cranberry plantations not only reduces their fire hazard but also does not disrupt the course of natural succession, which occurs in the mire-forming process and makes it possible to preserve the peat deposit.

References

[1] Vaseneva A Ya 1972 Wild berry fields of the Middle Amur Basin *Productivity of wild berry fields and their economic value* (Kirov: VNIIOZ) pp 128–30
[2] Kopoteva T A and Kuptsova V A 1997 Phytocenotic peculiarities and productivity of berry of *Oxyccoccus palustris* Pers. in Pryamurie *Russian J. of Plant Res.* 33(4) 75–80
[3] Kopoteva T A 1993 *Structure of plant matter and productivity dynamics of Pryamurie’ bogs* Candidate thesis (Khabarovsky: IWEP FEB RAS)
[4] Kopoteva T A and Kuptsova V A 2011 Pyrogenic factor on the Pryamurie bogs *Bull. of NERC FEB RAS* 2 37–42
[5] Kopoteva T A and Velikov A V 2008 Results of introduction of cranberry varieties on the south of Russian Far East *Bull of KrasSAU* vol 5 (Krasnoyarsk: KrasSAU) pp 118–25
[6] Kuptsova V A 2020 Organization of American cranberry mother plantation under coverage *Agricultural J. of FEFD* 2(54) (in print)
[7] Kudinov M A and Sharkovsky E K 1979 *Recommendations to establish plantations of northern American large-fruited cranberry*
[8] Scientific-applied handbook on climate of USSR 1991 (Moscow: Hydrometeioizdat) vol 25
[9] Resources of surface waters of USSR: Hydrological knowledge 1970 Russian Far East. (Leningrad: Hydrometeioizdat) vol 18(2)
[10] Main directions on conservation and management of peatbogs of Russia 2003 (Moscow:
Russian program of International bureau on wetland conservation

[11] Moiseeva T R 2013 For the forest products Forest and hunting industry 1 9–12
[12] Titok V V et al. 2012 Central botanical garden of NAS of Belarus: conservation, studying and using biodiversity of world flora (Minsk: Belarus navuka)
[13] Freidin M Z and Vasiliev V V 2000 The increase in economic effectiveness of growing and harvesting Vaccinium plants Bull. of NAN of Belarus. Series of agricultural sciences 4 100–7