

Assessment of the resistance of strawberry varieties to major diseases in the south of Sakhalin

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Abstract. The article presents the main diseases of garden strawberries in the monsoon climate of the island. Sakhalin - gray rot and white spot. Observations were carried out from 2017 to 2020 in the experimental nursery of the Federal State Budgetary Scientific Institution "Sakhalin Research Institute of Agriculture". The purpose of the research was to assess the introduced varieties of garden strawberry for resistance to diseases with the selection of the most resistant varieties for its further introduction. The objects of study were 21 varieties of garden strawberry. As a result of the research, varieties that are complexly resistant to white spot and gray rot were identified: Amulet, Deroyyal, El'santa. Deroyyal, El'santa, Figaro, Sal'sa, Tago. Varieties with resistance to white spot are distinguished: Tanyusha, Rumba, Evi, Amulet, Deroyyal, El'santa, Cheburashka. Varieties with weak, 1 point susceptibility to one of the diseases - Rumba, Evi, Cheburashka, Kleri, Podarok sud'by, Vima Zanta, Figaro, Tago, Sal'sa. The most affected strawberry varieties to gray rot disease were noted in 2020. The most favorable for the development of white spot disease developed in 2018, 2020, associated with the temperature regime of the air in these years, where the sum of effective temperatures was 781 ° C and 830 ° C. and farms.

1 Introduction

Strawberry (*Fragaria ananassa*) is one of the most popular and widespread berry crops grown in gardens and cottages around the world. Strawberries are valued for early fruiting, early ripening, taste, nutritional properties and biochemical composition [1-3].

Garden strawberries are grown in large quantities in almost all climatic zones of the world. In some countries, such as the European Union, North America, Japan, Australia, fresh strawberries are consumed all year round [4]. Annually, the average production of berries is more than 6.7 million tons. The largest producers of this berry crop - strawberries are China, USA, Mexico, Turkey, Egypt, Spain, Korea, Russia, Poland, Japan.

To obtain high stable yields of strawberries, it is important to select varieties with high adaptive potential that can withstand damaging factors. Each region has its own varieties that adapt to local soil and climatic conditions and have high productivity, quality

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indicators of berries, resistance to pests and diseases, so the main indicator of success in growing crops is the variety. The study of signs of damage to strawberry plants by various diseases and pests and the main ways to deal with them showed that it is the variety, variety genotype and weather conditions of the growing season of the region that affect resistance to major viral and phytoplasmic diseases.

The ability of garden strawberry to reproduce quickly vegetatively, its precocity, plasticity and yield are very cost-effective for cultivation, however, like any plant, it is susceptible to diseases that reduce yield, quality of berries, and even to its death. Viral diseases are one of the main reasons for the degeneration of garden strawberry varieties in different zones of cultivation of this crop.

The main preventive measures to combat diseases are: the selection of resistant varieties, the use of healthy planting material, the containment of the development of diseases by the use of fungicides before and after harvest. Cultivation of varieties with high resistance to diseases in the monsoon climate of Sakhalin will undoubtedly help reduce the pesticide and economic burden, as well as contribute to the production of environmentally friendly, safe products.

Major diseases such as gray rot of berries, powdery mildew, leaf spot and many other diseases cause great damage in the cultivation of strawberry plantations. There are more than 20 strawberry diseases that affect the vegetative and generative parts of the plant [5]. Long-term studies have shown that the main, most common diseases of strawberries in the conditions of the island are gray rot and white spot.

Gray rot of berries is one of the most dangerous and harmful diseases of strawberries, which is caused by the fungus *Botrytis cinerea* Pers, the causative agent of which parasitizes on the crop all year round at a temperature of 0–35 °C. Warm and humid weather contributes to the development of the disease [6]. This fungus affects both strawberry fruits and flowers, leaves and stems. As a result of the disease, strawberries may become unfit for human consumption. This disease is widespread in regions with high rainfall and lack of heat. Therefore, it is important to maintain optimal conditions for growing garden strawberries and apply preventive measures to prevent the occurrence of gray mold.

Studies have shown that resistance to gray mold may be related to the presence of certain genetic markers responsible for the production of defense compounds in the plant. Currently, there are no varieties with complete immunity to this disease. All varieties perform differently, depending on the climatic conditions of growth, some show a higher degree of resistance to gray rot than others, so other factors such as: humidity, temperature, plant nutrition, etc. should be taken into account.

White spot is a disease caused by the fungus *Ramularia tulasnei* Sacc. There are several strains of this fungus and varieties that are resistant in one region may be susceptible in another [7].

Varieties resistant to one strain of the fungus can be affected by other strains and vary greatly in their resistance. This disease affects the leaves of strawberries, causing white spots on their surface, which then turn brown and dry, if severely affected, it can lead to drying and shedding of leaves. Bushes do not completely die from white spot, but an increase in leaf damage leads to a decrease in yield by 10–15 and even 40% [8]. The disease also affects petioles, peduncles, stalks, sepals. The first signs are found in the spring, mainly in mid-May and at the end of the harvest.

Each locality has its own varieties that adapt to soil and climatic conditions, have high productivity, quality indicators of berries, resistance to pests and diseases, so the main indicator that determines the success in growing crops is the variety. The study and further introduction of disease and pest resistant varieties of strawberries can reduce the pesticide load and obtain environmentally friendly products [9, 10].

2 Materials and methods

The study was carried out for four years, from 2017 to 2020, in the conditions of the monsoon climate of Sakhalin Island. Field observations were carried out in the experimental nursery of the Federal State Budgetary Scientific Institution "Sakhalin Scientific Research Institute of Agriculture". The plots for laying experiments are typical for the zone, leveled along the relief. The soil of the experimental plots is medium loamy, with an average degree of cultivation. fertilizers were carried out for plowing at the rate of 100 t / ha, mineral phosphorus-potassium fertilizers - at the rate of 30 - 45 g of superphosphate (P_2O_5 - 26%) and 15 - 25 g of potassium sulfate (K_2O - 50%) per 1 sq. m. was carried out as weeding, from two to four times during the growing season [11].

The objects of research were 21 varieties of garden strawberries, domestic and foreign selection: Rubinovyy kulon, Podarok sud'by, Cheburashka, Sal'sa, Syurpriz Olimpiade, Figaro, Balerina, Kleri, Solnechnaya polyanka, Talantlivaya, Deroyyal, Tago, El'santa, Schastlivaya, Vima Zanta, Evi, Torpedo, Rumba, Amulet, Tanyusha, Felitsiya. Control variety - Torpedo. Planting date - autumn 2015, spring 2016.

Records and observations were carried out according to the method of variety study of fruit and berry crops of the All-Russian Research Institute of Fruit Crop Breeding, 1999 [12]. The assessment of varieties for diseases was carried out against a natural infectious background. The degree of damage to strawberry varieties by gray rot was carried out at the time of harvesting by the number of affected and the total number of harvested berries, by counting with conversion to a percentage using a five-point system. The resistance of varieties to leaf spots was carried out in the second half of summer, also using a 5-point scale developed by VNIIR: 0 - no damage; 1 - weak lesion, no more than 10 small ones per leaf; 2 - medium lesion: spots occupy up to 25% of the leaf surface, sporulation is clearly visible; 3 - severe damage: large spots of mycelium, occupying 26-50% of the leaf area, abundant sporulation; 4 - very strong defeat: large spots occupy more than 50% of the leaf area, sporulation is abundant, the leaf dies off.

The climate of Sakhalin is moderately monsoonal, the study area is characterized by an average annual air temperature of 3.1 °C, an average annual rainfall of 500 to 850 mm, a sum of active temperatures of 1800-2200 °C, which are generally relatively favorable for the growth and development of berry crops. The main unfavorable conditions include a slow increase in temperature in spring and rather frequent breaks in rainfall at the beginning of the season. At the same time, high air humidity and a significant amount of precipitation throughout the growing season contribute to the intensive growth of berry crops.

3 Results

During the study period, the temperature regime was kept at the level of average long-term values. The height of snow cover in plantations for the studied years ranged from 91 to 213 cm. An important indicator that determines the adaptability and stability of fruiting varieties is winter hardiness. For all the years of study, freezing of growth buds and root systems was not observed on any variety, a constant powerful snow cover completely protected plants from freezing in winter. Moisture supply and temperature conditions differed, which was reflected in the timing of the passage of its main phenological phases of development.

The average indicators of the beginning of the growing season of strawberries fall at the end of May, the beginning of June. Beginning of flowering in the first or second decade of June. The beginning of ripening of berries comes from the second decade of July, the end of ripening is the third decade of July, the first decade of August. The duration of the phenophases depends on the characteristics of each variety.

In the course of studying the variety samples from Table 1, it can be seen that 2017-2018 were the most favorable years for the normal development of plants, in all 21 varieties of garden strawberry, gray rot was not detected (Table 1).

Table 1. These lesions of strawberry varieties with garden gray rot and white spot.

Variety	Degree of damage, score							
	The degree of damage to gray rot				Degree of white spotting			
	2017	2018	2019	2020	2017	2018	2019	2020
Torpedo (St.)	0	0	0	1	0	1	1	1
Felitsiya	0	0	0	1	0	1	1	1
Solnechnaya polyana	0	0	1	2	1	1	1	2
Tanyusha	0	0	1	2	0	0	0	0
Rumba	0	0	0	1	0	0	0	0
Amulet	0	0	0	0	0	0	0	0
Evi	0	0	0	1	0	0	0	0
Vima Zanta	0	0	0	0	0	1	1	1
Podarok sud'by	0	0	0	0	0	1	0	1
Kleri	0	0	0	0	0	0	0	1
Talantlivaya	0	0	0	1	0	1	1	2
Schastlivaya	0	0	0	1	0	1	1	1
Deroyyal	0	0	0	0	0	0	0	0
El'santa	0	0	0	0	0	0	0	0
Balerina	0	0	0	1	1	1	1	1
Syurpriz Olimpiade	0	0	0	1	0	1	0	0
Cheburashka	0	0	0	1	0	0	0	0
Figaro	0	0	0	0	0	1	1	1
Sal'sa	0	0	0	0	0	1	0	0
Rubinovy kulon	0	0	2	2	0	1	1	1
Tago	0	0	0	0	0	0	0	1

In 2019, in the form of weak lesions (1 point), the first symptoms of gray rot disease appear on the varieties Solnechnaya Polyana and Tanyusha, which makes up 10% of the collections. The average damage (2 points) was recorded in the variety Rubinovy kulon (5%).

Some scientists note that in addition to immunity, densely leafy varieties with medium and soft fruit density are more susceptible to this disease, in this case, the above varieties of garden strawberries have an average fruit pulp density.

In 2020, a weak degree of damage (1 point) was noted in 43% of strawberry varieties, these include varieties: Torpedo, Felitsiya, Rumba, Evi, Talantlivaya, Schastlivaya, Balerina, Syurpriz Olimpiade, Cheburashka. Average susceptibility to gray rot (2 points) was shown by 14% of strawberry varieties - P Rubinovy kulon, Solnechnaya polyana, Tanyusha. The following varieties had the most immune protection: Amulet, Vima Zanta, Podarok sud'by, Kleri, Deroyyal, El'santa, Figaro, Sal'sa, Tago.

The greatest defeat by the disease was noted in 2020, 57% of the collection of varieties. The development of the disease was facilitated by cool rainy weather during the mass ripening of berries, the age of plants, untimely harvesting of ripe fruits, and the presence of weeds.

The manifestation of symptoms of white leaf spot in 2017 to a lesser extent (1 point) was recorded on the varieties Solnechnaya Polyana and Balerina, which accounted for 10% of the collection of varieties.

In 2018, a weak defeat (1 point) by this disease was noted in 57% of the varieties: TTorpedo, Felitsiya, Solnechnaya polyana, Vima Zanta, Podarok sud'by, Schastlivaya, Talantlivaya, Balerina, Syurpriz Olimpiade, Figaro, Sal'sa, Rubinovy kulon.

In 2019, spotting damage of 1 point was noted in 48% of varieties. In 2020, 57% of the varieties had damage, in which the varieties Solnechnaya Polyana, Talantlivaya, weak had an average (2 points) signs of damage, 10 varieties had 1 point.

The annual defeat by white spotting was noted to varying degrees on the varieties: Solnechnaya Polyana and Ballerina.

During the study period, the relative resistance to white spot disease in different years was shown in the varieties: Tanyusha, Rumba, Evi, Amulet, Deroyal, Elsanta, Cheburashka, which accounted for 33% of the entire collection.

4 Discussion

According to annual temperature readings (Table 2), during the years of research, the highest sum of effective temperatures was noted in 2019 - 1741 °C, then in descending order were 2017 - 1472 °C, 2020 - 830 °C, 2018 - 781 °C.

Table 2. Temperature during flowering and ripening of strawberries by years.

Year	Air temperature, °C						
	average monthly			sum of effective temperatures			
	May	June	July	May	June	July	Total
2017	9.0	10.7	17.7	126	248	549	1472
2018	8.1	10.7	15.6	94	214	473	781
2019	12.5	11.9	16.0	222	516	1003	1741
2020	7.9	11.7	16.5	44	274	512	830

According to the amount of precipitation during the study years (Table 3), it can be seen that the most precipitation fell in 2019 - 344.3 mm, then in decreasing order in 2017 - 249.7 mm, 2018 - 230.5 mm, 2020 d - 161.1 mm. By months, the largest amount of precipitation was recorded in July 2017 - 136.3 mm and in June 2019 - 124.0 mm.

Table 3. Rainfall during flowering and fruit ripening.

Year	Decade	The amount of precipitation, mm			
		May	June	July	Total
2017	I	11.0	16.2	25.2	52.4
	II	2.2	21.6	46.8	70.6
	III	8.7	53.4	64.6	126.7
	sum	21.9	91.2	136.6	249.7
2018	I	30.4	18.1	15.1	63.6
	II	29.7	16.7	61.8	108.2
	III	12.2	38.3	8.2	58.7
	sum	72.3	73.1	85.1	230.5
2019	I	14.5	10.5	13.3	38.3
	II	1.3	62.4	1.1	64.8
	III	20.6	51.1	48.9	120.6
	sum	36.4	124.0	63.3	344.3
2020	I	18.7	18.8	27.2	64.7
	II	19.9	19.2	3.8	42.9
	III	20.1	16.9	16.5	53.5
	sum	58.7	54.9	47.5	161.1

The spread of strawberry white spot disease is associated with the beginning of the growing season of plants, which increases until the harvest period and continues until the

end of the growing season. Thus, the most favorable conditions for the development of this disease developed in 2018 and 2020, where the sum of effective air temperatures in these years was almost two times lower and amounted to 781 ° C and 830 ° C. Compared with 2017 and 2019, the sum of effective temperatures was equal to 1472 and 1741 ° C. The amount of precipitation during flowering and fruit ripening (June-July) of these observation years should also be taken into account, then 158.2 mm (2018), 102.4 mm (2020) of precipitation fell. Thus, the presence of precipitation with lower air temperatures compared to previous years contributed to the development of the white spot disease in these years.

Insignificant damage by white spot in 2017 and 2019 of garden strawberry can be explained by the presence of more than in 2018 and 2020. the sum of effective temperatures, in 2017 - 1742 ° C, in 2019 - 1741 ° C, which, despite the amount of precipitation of 227.8 and 187.3 mm, did not contribute to greater distribution and development.

Undoubtedly, in addition to the correct choice of genetically resistant varieties of this crop, other factors contributing to the development of these diseases should also be taken into account.

5 Conclusion

As a result of the research, the most resistant strawberry varieties were identified, which are resistant to the main common diseases in the monsoon climate of southern Sakhalin.

Complex resistance to the main diseases common in this region, such as gray rot and white leaf spot, was shown by the varieties: Amulet variety, bred in Canada in 1973, medium ripening, bush medium-sized, compact, with large leaves, with a small number of mustaches, with high rates resistance to diseases and pests, with sweet dark raspberry-colored berries, with dense pulp. Deroyal is a variety bred by French breeders, of medium ripening, large-fruited throughout the entire harvest, with increased immunity to infections and high resistance to various climatic conditions. Elsanta is a variety bred in Holland in 1981, as a result of crossing Gorella and Holiday. The variety was included in the Russian register of breeding achievements in 2007. A plant of early medium maturity, medium size, with well-leafed bushes and developed mustaches, with dense and large fruits, with high rates of resistance to diseases and pests.

The above varieties have proven to be promising varieties with high immunity, suitable for cultivation without the effects of chemical treatments and possessing another set of economically valuable traits, such as productivity.

The greatest damage to strawberry varieties to gray rot disease was noted in 2020. The most favorable for the development of the white spot disease developed in 2018 and 2020.

Varieties with weak (1 point) susceptibility to one of the diseases include varieties: Rumba, Evi, Vima Zanta, Podarok sud'by, Kleri, Cheburashka, Figaro, Sal'sa, Tago.

Varieties Solnechnaya polyana, Talantlivaya were marked with an average susceptibility (2 points) to white spot, and Solnechnaya polyana, Rubinovyy kulon, Tanyusha were noted for gray rot.

The varieties Amulet, Vima Zanta, Podarok sud'by, Kleri, Deroyyal, El'santa, Figaro, Sal'sa, Tago were noted to be relatively resistant to gray rot disease, the varieties Tanyusha, Rumba, Evi, Amulet, Deroyyal, Elsanta, Cheburashka.

Based on many years of research, the identified varieties can later be recommended for cultivation in horticultural partnerships, household plots and farms in the region.

References

1. S.D. Aitzhanova, *Adaptive and productive potential of new strawberry varieties and selections*, Problems of agroecology and adaptability of varieties in modern horticulture in Russia, **1**, 3 (2008)
2. G. MacInnis, C.M. Buddle, J.K. Forrest, *Small wild bee abundance declines with distance into strawberry crops regardless of field margin habitat*, Basic and Applied Ecology, **44**, 14-23 (2020)
3. J. Aliman, M. Kazazic, E. Mehic, M. Djapo-Lavic, M. Smajic, J. Aliman, *Physicochemical and antioxidant properties of three strawberry cultivars and wild strawberry from central Bosnia region*, X International Symposium on Agricultural Sciences AgroReS, Trebinje, Bosnia and Herzegovina, 92-103 (2021)
4. O.Z. Metlitsky, *Modern production of fruits and berries*, Fruit growing and berry growing in Russia: Sat. scientific slave, Moscow, **5**, 20-26 (1998)
5. S.E. Golovin, *Root and basal rots of garden plants: prevalence, harmfulness, diagnostics*, Moscow, 439 (2016)
6. J.L. Maas, *Strawberry disease management*, In: S.A.M.H. Naqvi (ed.). Diseases of Fruits and Vegetables: Vol. II. Dordrecht: Springer; 441-483(2004)
7. D.Kh. Scott, *Strawberries*, Selection of fruit crops (Kolos, Moscow, 1981)
8. S.N. Oleichenko, *Yagodniki Kazakhstan*, Alma-Ata, 54 (1992)
9. A. Ludaskas, J. Repeckiene, N. Uslis, A.B. Rasinskien, *Problems of longtime strawberry growing in one plot*, Acta Sci. Paul, **2**, 2, 56-68 (2003)
10. J.L. Maas, *Strawberry Disease Management*, Diseases of Fruits and Vegetables, Netherland, **11**, 441-483 (2004)
11. A.A. Zhuchenko, *Genetic nature of the adaptive potential of cultivated plants*, Identified plant gene pool and selection, SPb., 36 (2005)
12. *Program and methodology for the study of variety of fruit, berry and nut crops*, Orel, 606 (1999)