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Monitoring the distribution and development of apple scab (*Venturia inaequalis*) and powdery mildew (*Podosphaera leucotricha*) disease in the southern and southeast regions of Kazakhstan

Apple (*Malus domestica*) is a very important fruit tree that is widely cultivated in different climatic regions of the world. Scab (*Venturia inaequalis* (Cooke) G.) and powdery mildew (*Podosphaera leucotricha*) are common fungal diseases in apple orchards. The harmful impact of these disease results in poor fruit size and quality, premature fruit fall, peeling, less fruit bud development in the next year's fruit buds. When the pathogen is present under favorable environmental conditions, disease develops highly, and the crop losses of up to 70 %. Phytosanitary monitoring for the spread and development of the scab and powdery mildew pathogen was carried out the main fruit tree-growing regions of Kazakhstan, namely, Almaty, Turkestan and Zhambyl regions apple-growing farms in 2022. Research was conducted on apple orchards on the territory of 14 ha in Almaty region, 288 ha in Turkestan region and 40 ha in Zhambyl region. We carried out a phytopathological assessment of fungal disease for following commercial varieties Starkgrimson, Zolotoy presvesov, Aidaret, Americanka, Samured, Gala, Fuji and Golden Delicious grown in these regions. According to the results of the study, there were no symptoms of powdery mildew in Almaty and Zhambyl regions. Furthermore, powdery mildew distribution was 18.05 % in the Aidaret, while its development was at a lower level of 3.06 % in the apple orchards where Tulkibas district of Turkestan region. Scab pathogen is present in all orchards of the studied regions. The pathogen *Venturia inaequalis* was spread at an average level with 23-31 % in Starkgrimson, Zolotoy presvesov and Aidaret varieties, while its development was at a low level with 1-2.84 % in the Almaty region. The disease distribution is with 30-37 % of orchards where Starcrimson, Golden Delicious and Red Delicious varieties are grown in the Zhambyl region. As well as the development of the disease was 2-4.12 %. In the Turkestan region, in Samured and Starkrimson varieties, scab distribution was at a low level with 3-3.71 %, while the development of the disease was with 0.50-0.81 %. In Idared and Gala varieties, the disease distribution in the range about 16-17 %, while the development developed at a lower level with 0.13-1.25 %. The Fuji was recognized as resistant variety to scab, for the reason of no disease symptoms.

Keywords: apple tree, phytopathology, powdery mildew, scab, fungus, resistant, pathogen, breeding.

Introduction

In many parts of the world, one of the most important fruit crop in Kazakhstan is the apple tree. According to the information of agriculture, Kazakhstan people consume 344.3 thousand tons of apples annually, 144 thousand tons of which are imported. Providing the domestic market is expected due to the construction of new intensive gardens covering an area of 6.6 thousand hectares. The main fruit-producing areas of Kazakhstan are the southern regions — South Kazakhstan — 18,024.6 ha, Almaty region — 16,180.7 ha and Zhambyl region — 5,794.7 ha. The natural and climatic conditions of these regions are suitable for growing high-quality fruits that can compete with foreign products [1]. Kazakhstan plans to supply the entire country with apple production by 2024 [2].

Venturia inaequalis (Cooke) G. Winter, the apple scab pathogen, causes significant damage to fruit production, lossing level of product quality and yield up to 70 %. For developing of apple scab, favorable conditions are abundant rainfall in the last month of spring and early summer [3]. The main economic impact is due to the reduction in both size and marketable quality of the fruit, as well as decreasing the vitamin level [4]. Studies conducted by domestic and foreign scientists show the wide intraspecies heterogeneity of the fungi, which ensure its survival [5]. Powdery mildew is a fungal disease that spreads by spores in summer and affects most garden crops. The disease overwinters in plant buds. The growth of shoots infected with powdery mildew are damaged, dried up, leaves curl and fall down. It is difficult to fight this disease, so it is

easier to prevent by planting apple varieties resistant to this disease in the garden. Scab is one of the most harmful diseases, develops rapidly in moderately warm and humid weather, and is actively manifested in densely planted and frequently watered gardens. The causative agent of the disease overwinters in fallen leaves and bark of infected plants. In the spring, spores of the fungus multiply and then spread with the help of raindrops, insects and wind, damaging young leaves and shoots. Only varieties resistant to this disease should be planted in wet weather regions [6].

The main task of the modern breeding of fruit crops is to create varieties with economic valuable traits, resistant to important diseases. Scab (*Venturia inaequalis*) and powdery mildew (*Podosphaera leucotricha*) are the most harmful fungi of apple trees [7]. Apple breeding has the same difficulties as other fruit crops, such as the length of the ontogenetic development period, the presence of heterozygous varieties and forms at a high level under the influence of cross-pollination [8]. In the biology of fruit crops, time is spent on its reproduction and cultivation. Thus, it takes at least 8-10 years to obtain one adult fruit-bearing generation of an apple tree, even using vegetative forms, which limits not only the first hybrid generation needed as starting material, but also the second and third generation in genetic research by traditional methods. The fight against scab and powdery mildew disease is carried out mainly by phytopathological monitoring and maintaining the agrotechnology of growing fruit crops, as well as creating varieties resistant scab [9]. There is a need to develop new tools and methods for protecting plants from diseases, to optimize measures to combat scab and powdery mildew using modern approaches [10]. The purpose of the research: to carry out phytosanitary monitoring of the distribution and development of scab and powdery mildew diseases in apple orchards of the southern and southeastern regions of Kazakhstan and to identify disease-resistant apple varieties.

Experimental

The distribution and development degree of scab and powdery mildew were determined in the main apple-growing regions orchards of Almaty, Zhambyl and Turkestan regions. Phytopathological evaluation of varieties Starkgrimson, Zolotoy preoshesod, Aidaret, Americanka, Samured, Gala, Fuji and Golden Delicious for fungal disease. According to the phytopathological method, the distribution and development degree of the disease was determined [11].

The distribution of diseases was determined by the percentage of counted infected plants and the total number of registered plants. Calculation was conducted by using formula 1 below:

$$P = n * 100/N \quad (1)$$

Here: P — the distribution of the disease (%),

n — the number of infected plants,

N — the number of total registered plants.

During the phytopathological assessment, 25 leaves are evaluated from 4 sides of one tree, as a result, 100 leaves are taken into account [12].

The degree of developed disease was accounted by the scale:

Here: 0 — no visible symptom;

1 score — single spots, 10 % of the leaf surface was damaged;

2 score — spots occurred from 10 to 30 % of the leaf surface;

3 score — spots occurred from 30 to 50 % of the leaf surface;

4 score — over 50 % of leaf surfaces covered by spots.

Calculation of disease development degree was carried out by the formula 2:

$$R = \Sigma (a \cdot b) + (a \cdot b) \dots * 100/ NK \quad (2)$$

Here: R — the degree of development of the disease, %;

Σ — the sum of the products of a and b;

a — the number of leaves, fruits or trees with the same signs of disease development;

b — the score of the lesion corresponding to this sign;

N — the number of accounted leaves, fruits or trees;

K — the heavy infection score.

MM 106 and M 9 trees were used as a rootstock for varieties grown in orchards. The rootstock MM 106 is the most popular and deeply studied clone rootstock not only in European countries, but also in Russia and the CIS countries. This rootstock of apple trees is not only popular among professional gardeners, but also among amateur gardeners. The meaning of the MM series in the breeder means that it was obtained by the joint efforts of British breeders of the Merton Institute and the Mollinsk Experimental Station by crossing the M1 variety with the Northern variety. The dwarf MM 106 belongs to the group of semi-dwarf and medium-sized dwarfs. And M9 is the most common dwarf rootstock for apple trees. The height of the trees in this rootstock depends on the growth strength of the variety, but in any case it does not exceed 2.5-2.7 m. Life expectancy of rootstock M9 trees is 30-40 years. It takes three to four years to bear fruit [13].

Results and discussion

In the autumn-winter period, the overwintering state of scab pathogen is determined. At the beginning of summer, ascospores are detected in the “Green tip” and “Tight cluster” phases, and the damaging level by fungal diseases is assessed. Further, monitoring is carried out 2-3 weeks after flowering at the beginning of fruit ripening to evaluate the effectiveness of the protection scheme. The flight of scab ascospores is considered in dynamics in laboratory conditions, the infection degree of new leaves and fruits are directly registered in the garden. Phytosanitary monitoring was conducted from June 10 to July 30, 2022 in order to determine the distribution and development of apple scab and powdery mildew diseases. The research was carried out in orchards of apple-growing farms of Almaty, Zhambyl and Turkestan regions. The main cultivated apple varieties in these regions are Starkgrimson, Zolotoy prevoskhod, Aydaret, Americanka, Samured, Gala, Fuji and Golden Delicious. M9 and MM 106 were used as rootstock varieties of these varieties (Table 1).

Table 1

Distribution and development of scab and powdery mildew disease in apple orchards in Almaty region

Rural district, farm	Varieties	Root stock varieties	Field area, ha	Disease development index, %				Coordinates
				Scab		Powdery mildew		
				P	R	P	R	
Region: Almaty. District: Enbekshikazak — 2022								
Baydibekbi farm “Akkazy”	Stark Grimson	M 9	4	28,33	2,84	0	0	N 43°39'.930" E 77°86'.171"
Baydibekbi farm “Akkazy”	Zolotoy prevoskhod	MM 106	4	31,31	2,76	0	0	N 43°39'.930" E 77°86'.171"
Baydibekbi farm “Akkazy”	Aydaret	M 9	4	23,33	1,108	0	0	N 43°39'.930" E 77°86'.171"
Baydibekbi farm “ErmeK”	Amerikanka	MM 106	2	0	0	0	0	N 43°32'49.344" E 77° 52' 3.468"
Baydibekbi farm “ErmeK”	Aydaret	MM 106	2	0	0	0	0	N 43°32' 49.344" E 77° 52' 3.468"

Note — P — distribution, R — development.

During the research, infected leaves and fruits' samples were collected from gardens in different regions, and a herbarium was created.

Monitoring was carried out in the apple orchards of Akkazinsky and Yermek farms with an area of 14 hectares in the Enbekshikazakh District of Almaty region. These gardens are located at the foot of the Zailiyskiy Alatau. There were no signs of powdery mildew in the Almaty region, while scab disease distribution was about 23-31 % in the Starkgrimson, Golden prevoskhod and Aidaret varieties, the development was low with 1-2.84 %. The Americanka and Aidaret varieties showed no signs of disease.

At the next stage of the research, monitoring of apple orchards in the Turkestan region was carried out. The monitored total area was 288 hectares. There were no signs of the spread and development of powdery mildew disease in the Kazygurt District of Turkestan region. In the Samurai and Starkrimson varieties, distribution of scab was low approximately 3-3.71 %, the development of the disease was 0.50-0.81 %. The disease distribution was from 16 to 17 % in Aydared and Gala varieties, the development was a lower level

with 0.13-1.25 % (Table 2). The Fuji variety was recognized as resistant to scab, no signs of the disease were observed.

Table 2

The distribution and development of scab and powdery mildew disease in apple orchards of the Turkestan region

Rural district, farm	Varieties	Root stock varieties	Field area, ha	Disease development index, %				Coordinate
				Scab		Powdery mildew		
				P	R	P	R	
Region: Turkestan District: Kazygurt — 2022.								
Kazygurt LLP “AknietAgro”	Samured	MM 106	33	3,7	0,51	0	0	N 41°36'7.637" E 69°22'2.022"
Kazygurt LLP “AknietAgro”	Stark Grimson	MM 106	33	3,71	0,81	0	0	N 41°36'7.637" E 69°22'2.022"
Kazygurt LLP “AknietAgro”	Idared	MM 106	33	16,64	1,25	0	0	N 41°36'7.637" E 69°22'2.022"
Kazygurt LLP “AknietAgro”	Gala	MM 106	33	16,66	0,13	0	0	N 41°36'7.637" E 69°22'2.022"
Kazygurt LLP “AknietAgro”	Fuji	MM 106	33	0	0	0	0	N 41°36'7.637" E 69°22'2.022"
Region: Turkestan District: Tulkibas — 2022.								
Tulkibas, Farm “Koktal”	Aydaret	MM 106	41	0	0	18,05	3,06	N 42°33'32.288" E 70°24'2.687"
Tulkibas, Farm “Koktal”	Golden Delicious	MM 106	41	0	0	0	0	N 42°33'32.288" E 70°24'2.687"
Tulkibas, Farm “Koktal”	Stark Grimson	MM 106	41	0	0	0	0	N 42°33'32.288" E 70°24'2.687"
Note: P — distribution, R — development; LLC — Private farm, SSC — Experimental-production farm.								

A Phytopathological assessment of powdery mildew and scab of Aidaret, Golden Delicious and Stark Grimson varieties grown on an area of 123 hectares was carried out in Tulkubas District of Turkestan region (Fig. 1). These apple orchards showed no signs of scab disease. And the powdery mildew disease distribution was with 18.05 % in the Aydaret Variety, the development was at a low level with 3.06 %. There were no disease signs in The Golden Delicious and Stark Grimson varieties with powdery mildew.

Phytopathological monitoring for the distribution of powdery mildew and scab was conducted in the apple orchards of Zhambyl region. LLP “Tosh Merkensky”, located in the Merke district, showed no signs of powdery mildew disease from the leaves and fruits in the apple orchards of the Merke district (Table 3). Scab distribution was at an average level of 30-37 % in gardens where the varieties Starkrimson, Golden Delicious and Red Delicious and the development of the disease was 2-4.12 %.

Among the fungal diseases of apples, powdery mildew and scab are pathogens that directly affect the loss of yield and quality. Fruit trees are widely grown in Almaty, Zhambyl and Turkestan regions of the country. During the fruiting period of apple trees, phytopathological monitoring for distribution and development of fungal disease was carried out in the apple orchards (Fig. 2).



Figure 1. Leaf infection with powdery mildew and scab scored with 4

Table 3

Distribution and development of scab and powdery mildew disease in apple orchards of Zhambyl region

Rural district, farm	Varieties	Root stock varieties	Field area, ha	Disease development index, %				Coordinates
				Scab		Powdery mildew		
				P	R	P	R	
Region: Zhambyl region District: Merke — 2022.								
LLP “TOSH Merkensky”	Stark Grimson	MM 106	13	31,48	2,27	0	0	N 42°48'.584" E 73°10'.387"
LLP “TOSH Merkensky”	Golden Delicious	MM 106	14	33,33	2,97	0	0	N 42°48'.584" E 73°10'.387"
LLP “TOSH Merkensky”	Red Delicious	MM 106	13	36,87	4,12	0	0	N 42°48'.584" E 73°10'.387"

Note: P — distribution, R — development; LLC — Private farm.

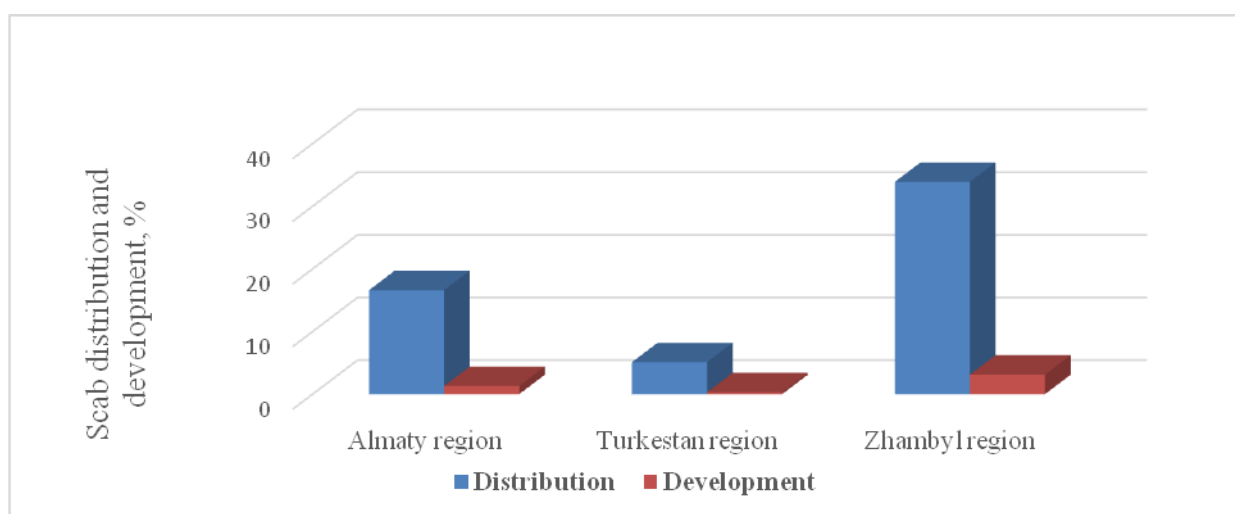


Figure 2. Distribution and development of scab in apple orchards of Almaty, Turkestan and Zhambyl regions, 2022

Powdery mildew was found only in Tulkibas district of Turkestan region among the regions that conducted a survey, in the Aydaret variety, the powdery mildew distribution was at the level of 18.05 %, and the development rate was at a low level with 3.06 %. Based on the results, scab distributed moderately in Zhambyl region among the regions that conducted the study. The highest distribution rate of the disease was 37 %, the development rate was 4.12 %.

Conclusion

In May and July 2022, phytosanitary monitoring of the distribution and development of scab and powdery mildew was carried out in apple orchards. The directions of the route study included peasant farms of Almaty, Zhambyl and Turkestan regions where the main apple-growing regions of the country. In apple orchards of the Almaty region, scab disease distributed in the average range of 23-31 % in the varieties Stark Grimson, Zolotoy prevoskhod and Aidaret, the development was in the lower range of 1-2.84 %. Phytopathological assessment of scab in apple orchards was carried out in the Turkestan region. In Kazygurt district, the spread of the pathogen was observed in the Samured and Stark Grimson varieties at a lower level of 3-3.71 %, and the development of the disease was with 0.50-0.81 %.

At the same time, in the Aydaret and Gala varieties, the disease distribution was in the range of 16-17 %, the development showed a lower level with 0.13-1.25 %. The leaves and fruits of the Fuji variety, grown in the apple orchards of this region, have been found to be resistant to the disease due to the fact that they do not show signs of scab. As a result of a route study in the apple orchards of Zhambyl region, the causative agent of *Venturia inaequalis* was distributed at an average level of 30-37 % by the varieties Starkrimson, Golden Delicious and Red Delicious. And the development of the disease was with 2-4.12 %. In the apple orchards of Almaty and Zhambyl regions, there were no signs of powdery mildew disease. And in the koktal farm in Tulkubas District of Turkestan region, the spread of powdery mildew in the Aydaret variety was with 18.05 %, the development showed a low level of 3.06 %.

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Қазақстанның оңтүстік және оңтүстік-шығыс аймақтарында алманың таз қотыры (*Venturia inaequalis*) және ақ ұнтақ (*Podosphaera leucotricha*) ауруының таралуы мен дамуына мониторинг

Алма (*Malus domestica*) — әлемнің әртүрлі климаттық аймақтарында кеңінен өсірілетін өте маңызды жеміс ағашы. Таз қотыр (*Venturia inaequalis* (Cooke) G.) және ақ ұнтақ (*Podosphaera leucotricha*) алма бақтарында кең таралған саңырауқұлақ аурулары. Қоздырғыш салдары жемістердің көлемі мен сапасының төмендеуіне, жемістердің мерзімінен бұрын түсуіне, қабыршақтануына, келесі жылғы жеміс бүршіктерінің нашар дамуына алып келеді. Ауруға қолайлы жағдай болған жылдары патоген жоғары деңгейде дамып, өнім 70 %-ға дейін жоғалуы мүмкін. 2022 жылы Қазақстанның негізгі жеміс ағаштарын өсіретін аймақтары Алматы, Түркістан және Жамбыл облыстарының алма өсіретін шаруа қожалықтарында таз қотыр мен ақ ұнтақ патогенінің таралуы мен дамуына фитосанитарлық мониторинг жүргізілді. Алматы облысында 14 га, Түркістан облысында 288 га, Жамбыл облысында 40 га аумақтағы алма бақтарына маршруттық зерттеу жасалды. Бұл аймақтарда өсірілетін «Старкгримсон», «Золотой превосход», «Айдарет», «Американка», «Самуред», «Гала», «Фуджи» және «Голден Делишес» сияқты коммерциялық сорттарының саңырауқұлақ ауруына фитопатологиялық бағалау жүргізілген. Зерттеу нәтижесі көрсеткендей Алматы және Жамбыл облыстарында ақ ұнтақ ауруының белгілері байқалмады. Ал Түркістан облысының Түлкібас ауданының алма бақтарында ақ ұнтақ ауруы «Айдарет» сортында 18,05 % деңгейде таралса, дамуы 3,06 % төменгі деңгейде залалданған. Таз қотыр патогені зерттеу жүргізілген аймақтардың барлық бақтарында кездесті. Алматы облысында *Venturia inaequalis* қоздырғышы «Старкгримсон», «Золотой превосход» және «Айдарет» сорттарында 23-31 % аралығында орташа деңгейде таралса, дамуы 1-2,84 % аралығында төменгі деңгейде болды. Жамбыл облысында ауру «Старкгримсон», «Голден Делишес» және «Ред Делишес» сорттары өсірілетін бақтарда 30-37 % орташа деңгейде таралған. Ал аурудың дамуы 2-4,12 % құрады. Түркістан облысында «Самуред» және «Старкгримсон» сорттарында таз қотыр 3-3,71 % төменгі деңгейде таралса, аурудың дамуы 0,50-0,81 %-ды құрады. «Айдаред» және «Гала» сорттарында ауру 16-17 % аралығында таралса, дамуы 0,13-1,25 % төменгі деңгейде дамыды. Таз қотырға «Фуджи» сорты төзімді деп танылды, аурудың белгілері байқалмады.

Кілт сөздер: алмалар, фитопатология, ақ ұнтақ, таз қотыр, саңырауқұлақ, төзімділік, патоген, селекция.

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Мониторинг распространения и развития болезней яблоневой парши (*Venturia inaequalis*) и мучнистой росы (*Podosphaera leucotricha*) в южных и юго-восточных регионах Казахстана

Яблоня (*Malus domestica*) — очень важное фруктовое дерево, широко выращиваемое в различных климатических зонах во всем мире. В яблоневых садах распространенными грибковыми заболеваниями являются парша (*Venturia inaequalis* (Cooke) G.) и мучнистая роса (*Podosphaera leucotricha*). Вредные последствия этих болезней приводят к снижению размеров и качества плодов, преждевременному их опаданию, шелушению, плохому развитию плодовых почек следующего года. В те годы, когда условия благоприятны для заболевания, патоген развивается очень сильно и урожай может быть потерян до 70 %. В 2022 г. был проведен фитосанитарный мониторинг распространения и развития патогенов парши и мучнистой росы в хозяйствах, выращивающих яблони, основных регионов Казахстана — Алматинской, Туркестанской и Жамбылской областей. В Алматинской области маршрутное обследование яблоневых садов проводилось на площади 14 га, в Туркестанской — на 288, в Жамбылской — на 40 га. Осуществлена фитопатологическая оценка грибковых заболеваний коммерческих сортов «Старкгримсон», «Золотой превосходный», «Айдаред», «Американка», «Самуред», «Гала», «Фуджи» и «Голден Делишес», выращиваемых в этих регионах. Результаты исследований показали, что в Алматинской и Жамбылской областях признаков болезни мучнистой росы не наблюдалось. В яблоневых садах Тюлькубасского района Туркестанской области мучнистая роса была распространена у сорта «Айдаред» на 18,05 %, а ее развитие было на низком уровне — 3,06 %. Возбудитель парши отмечался во всех садах регионов, где проводились исследования. В Алматинской области возбудитель *Venturia inaequalis* был распространен в средней степени в пределах 23–31 % у сортов «Старкгримсон», «Золотой превосходный» и «Айдаред», а его развитие было на низком уровне 1,0–2,84 %. В Жамбылской

области распространение болезни приходится на 30–37 % садов, где выращиваются сорта «Старкримсон», «Голден Делишес» и «Ред Делишес». А развитие болезни достигало 2,0–4,12 %. В Туркестанской области у сортов «Самуред» и «Старкримсон» распространение парши установлено на низком уровне 3,0–3,71 %, а показатель развития болезни составил 0,50–0,81 %. У сортов «Айдаред» и «Гала» заболевание распространилось в пределах 16–17 %, а развитие было в низкой степени 0,13–1,25 %. Сорт «Фуджи» признан устойчивым к парше из-за отсутствия признаков болезни.

Ключевые слова: яблоня, фитопатология, мучнистая роса, парша, грибок, устойчивый, патоген, селекция, снижение размера и качества плодов.

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