sciendo

Current Agronomy

IUNG

doi: 10.2478/cag-2024-0007

Current Agronomy
2024, 1: 61–68

Alternariosis or brown spot of pomegranate bushes in the western part of Azerbaijan

*Lala A. Huseynova**

Scientific Research Institute of Plant Protection and Industrial Crops, Republic of Azerbaijan

*Corresponding author: e-mail: fitopatoloq.Lale@mail.ru

Abstract. Alternariosis or brown spot (*Alternaria alternata* (Fr.) Keissl.) is a widespread disease of pomegranate bushes in Azerbaijan. The disease occurs mainly in the western part of the country. Alternariosis or brown spot on pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) is found mainly on leaves and fruits. On ripening pomegranate fruits, the lesion begins with small brown or black spots that increase in size and become round or oval. The causative agents of alternariosis or brown spot on pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) are imperfect fungi of the genus *Alternaria*, from the order Hyphomycetales; *Alternaria alternata* (Fr.) Keissl is more common in the conditions of the western part of Azerbaijan. Alternariosis or brown spot (*Alternaria alternata* (Fr.) Keissl.) causes the greatest harm in conditions of sufficient moisture.

The aim of the article is to present the results of studies on the distribution, intensity of development and harmfulness of alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.), as well as biological effectiveness of fungicides used to control alternariosis, in the western part of Azerbaijan. Research methods used are generally accepted in phytopathology and plant protection to identify and record the infectious potential of the causative agent of alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) as well as to disease monitoring. During field studies, the fungicides used were 0.4% Selphate (37.5% copper oxychloride + 16% zineb), 0.05% Azoxifene (20% azoxystrobin + 12.5% difenoconazole), 0.05% Conazole (25% difenoconazole) and 0.3% P-oxiride (50% copper oxychloride) and determined their biological effectiveness accordingly.

In the last 5 years, there has been a trend of increasing harmfulness of alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) in the western part of Azerbaijan. As our research results show, brown spot mainly affected the leaves of pomegranate bushes. Damage to pomegranate fruits differed only in certain years in the studied gardens. During field studies, it was found that the 0.4% fungicide Selphate gives the best results.

Keywords: pomegranate bush, alternariosis or brown spot, fungi, leaves, fruits, control measures

INTRODUCTION

Subtropical fruit crops, perennial evergreen, less often deciduous trees and shrubs, cultivated in the subtropics. Subtropical fruit crops include: pomegranate (*Punica* L.), olive (*Olea* L.), tea bush (*Thea* L.), fig (*Ficus* L.), feijoa (*Feijoa* Berg.), subtropical or Japanese medlar (*Eriabotrya japonica* Lindl.), oriental or subtropical persimmon (*Diospyros* L.), citrus fruits (*Citrus* L.), etc. Subtropical fruit crops are characterized by relatively low winter hardiness and a long growing season; they require more or less stable winter dormancy. The degree of frost resistance of individual crops varies greatly. Heat requirements during the growing season also vary (Grekov, 2002; Huseynova, 2021a; Huseynova, 2022b; Kopylov et al., 2019).

Pomegranate (*Punica* L.) is a shrub 2–3 m high (Fig. 1) or a small tree up to 3 m with thin branches, leathery leaves and large red-orange flowers. This is a relatively drought-

Figure 1. Pomegranate bush with ripe fruits (photo by the author).

resistant plant, but also tolerates high soil moisture. It grows well in places where the winter temperature does not drop below -12 °C, the summer is hot and long, the autumn is dry and warm and there are no sharp temperature fluctuations. Pomegranate bushes are grown in Crimea, Dagestan, the republics of Transcaucasia, Middle Asia, as well as in Afghanistan, Iran, Turkey and other countries (Dankov et al., 2014; Guliyev, Huseynova, 2020; Guliyev, Huseynova, 2021; Huseynova, 2021b).

One of the most important indicators that reduce the productivity of pomegranate bushes is fungal diseases (mycoses). The main diseases affecting pomegranate bushes in the western part of Azerbaijan are the following: zitiosis fruit rot (*Zythia versoniana* Sacc.), anthracnose or fruit scab (*Sphaceloma punicae* Bitank. et Jenk.), alternariosis or brown spot (*Alternaria alternata* (Fr.) Keissl.), phoma or branch cancer (*Phoma punicae* Tassi.), etc. (Huseynova, 2022a).

Alternariosis or brown spot (*Alternaria alternata* (Fr.) Keissl.) is a fungal disease that causes damage to the leaves, flowers and fruits of pomegranate bushes in the western part of Azerbaijan. Optimal conditions for infection are a temperature of 26–28 °C and high relative humidity of 65–70%. When temperature and humidity conditions are favorable for the spread and development of the disease, the first signs of alternariosis or brown spot (*Alternaria alternata* (Fr.) Keissl.) appear on pomegranate bushes 8–10 days after infection. Pomegranate bushes become infected with the corresponding disease through mycelium and conidiospores. The pathogen is spread by water and raindrops (hydrochoria) and, under favorable conditions, causes infection. The phytopathogenic fungus overwinters in the form of mycelium and conidiospores in weeds and plant debris on the ground. However, the pathogen cannot survive in soil (Huseynova, 2021a).

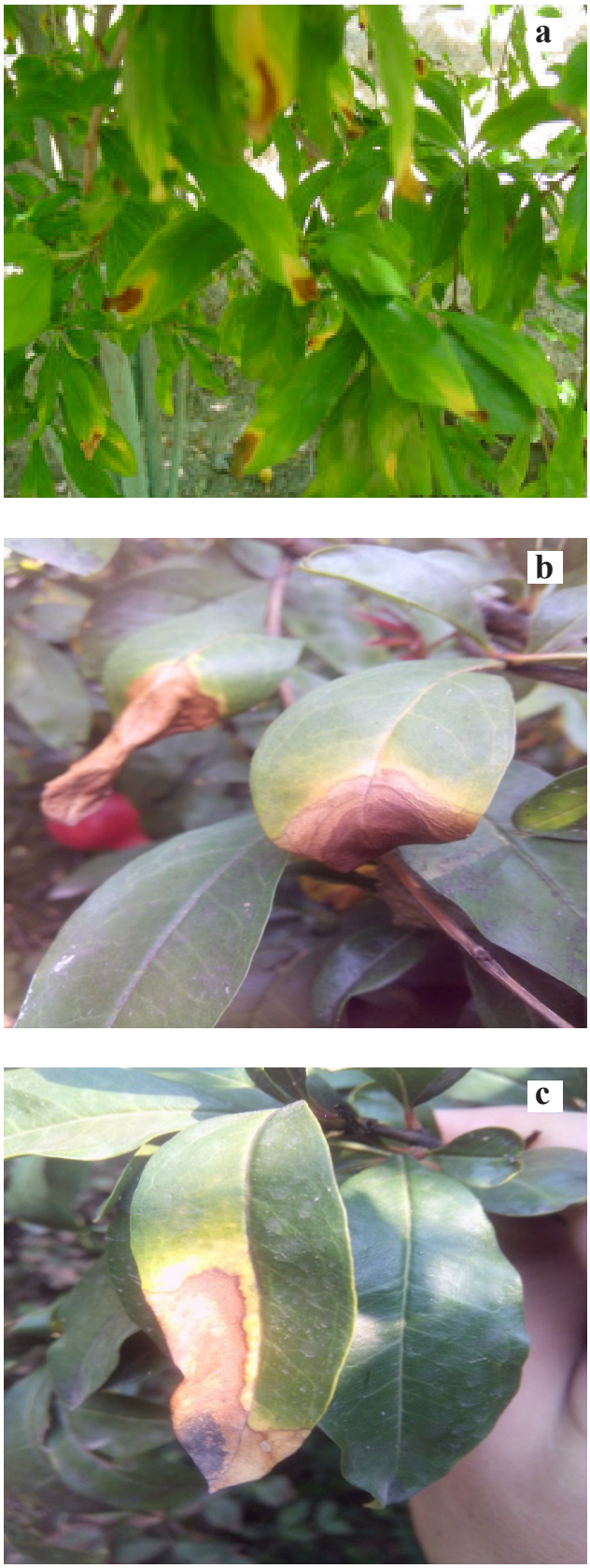

Figure 2 a, b, c. Leaves of a pomegranate bush affected by alternariosis or brown spot (photo by the author).

Figure 3 a, b. Pomegranate fruits affected by alternariosis or brown spot (photo by the author).

As the disease progresses, these spots expand and almost half of the leaves are damaged. And with severe infections, almost the entire part turns brown and dries out (Fig. 2 a, b, c). The disease is also observed in flowers and fruits (Fig. 3 a, b). In severe forms of infection, leaves and young fruits are dropped. Infection in fruits usually appears as dark brown large spots starting from the crown of the fruit, and brown spots also appear on the skin of the fruit.

Alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) is a disease of necrotic origin. Necrosis (from the ancient Greek "*necrosis*" – death) is a type of disease characterized by the death of any section of tissue or part of a plant. The causes of necrosis are: unfavorable abiotic factors (freezing, burns, friction, lack or excess of nutrients), chemical effects (spray burns), microorganisms (phytopathogenic fungi, bacteria, viruses). Necrosis is caused by microorganisms with necrotrophic and hemibiotrophic types of nutrition.

The main goal of the research work is to study the prevalence, intensity of development and harmfulness of alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) in the western part of Azerbaijan. To achieve this goal, during the research work carried out during 2018–2023, the following tasks were completed:

– Study of the prevalence, intensity of development and harmfulness of alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) in the western part of Azerbaijan;
– Collection of leaves and fruits infected with alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.), as well as their further study in the laboratory, determination and identification of the causative agent of the disease;
– Development of methods to combat alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) in the western part of Azerbaijan.

MATERIALS AND RESEARCH METHODS

In 2018–2023, in a pomegranate garden with an area of 19 hectares, located in the Goranboy region in the western part of Azerbaijan, the distribution, intensity of development and harmfulness of alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) were studied. In addition, route studies were carried out in other western regions such as Shamkir and Kazakh, including Goranboy. The harmfulness of brown spot on pomegranate bushes was studied on the susceptible local Azerbaijani cultivars "Kyrmyzy Kabukh" and "Pink Gulosha" to the disease. When taking into account the infestation of pomegranate in the examined bushes, the number and percentage of healthy and affected leaves and fruits were calculated.

Stationary observations were carried out in the Goranboy region, and route observations in the Goranboy, Shamkir and Kazakh regions. The variants were repeated three times in the experiment. 4 × 4 layout of pomegranate bushes in the garden.

During the scientific research we conducted in pomegranate gardens in the western part of Azerbaijan in 2018–2023, samples were taken – 100 leaves and 15 fruits from 4 sides of the crown of each pomegranate bush (60 fruits in total). Field experiments were carried out in 5 variants of 3-fold replication.

To determine the death of pomegranate leaves and fruits, surveys were carried out throughout the growing season. Fallen pomegranate leaves and fruits were collected for microscopic analysis. It should be noted that route surveys of pomegranate orchards were carried out 3 times during the growing season (immediately after flowering; one month later; before harvesting).

Laboratory studies to study brown spot on pomegranate bushes were carried out at the Central Phytosanitary Laboratory of the Institute of Food Safety.

Research methods are generally accepted in phytopathology and plant protection for identifying and recording the infectious potential of the causative agent of alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.), and in disease monitoring (Spooner, Roberts, 2005; Maheshwari, 2005; Deacon, 2006; Carlilae et al., 2001).

The intensity of damage to pomegranate leaves by alternariosis or brown spot (*Alternaria alternata* (Fr.) Keissl.) was assessed on the scale:

– 0 point – no lesion;
– 1 point – from 1 to 10% of the leaf surface is affected;
– 2 points – from 11 to 25% of the leaf surface is affected;
– 3 points – from 25 to 50% of the leaf surface is affected;
– 4 points – over 50% of the leaf surface is affected.

Alternariosis (*Alternaria alternata* (Fr.) Keissl.) on pomegranate fruits was taken into account on the scale:

– 0 point – healthy fruits;
– 1 point – there are single very small, barely noticeable spots on the fruit without cracks;
– 2 points – single spots (1–3), clearly visible, up to 0.5 cm in diameter;
– 3 points – a significant number of clearly visible spots, 0.5–1.0 cm in diameter;
– 4 points – spots are numerous, difficult to count, with a diameter of 1 cm or more.

Prevalence (P, %) was determined after counting diseased and healthy plants in the sample using the formula (Dyakov et al., 2011; Beloshapkina, 2017):

$$P = 100n/N$$

where: n – the number of diseased plants in the sample;
N – the total number of plants examined.

The intensity of disease development (R, %) was determined using the following formula (Popkova, 2005):

$$R = (100\sum(ab))/Nk$$

where: a – the number of diseased plants;
b – corresponding score of their defeat;
N – the total number of recorded plants (sick and healthy);
k – the highest score on the accounting scale.

Biological effectiveness was determined by the reduction in the development of brown spot (*Alternaria alternata* (Fr.) Keissl.) on the treated variants relative to the control (Shkalikov, 2001).

$$BE = (M_k\text{-}M_o)/M_k \times 100$$

where: M_k – the indicator of disease development in the control (protective measures were not carried out);
M_o – indicator of disease development in the experiment (with protective measures).

Field experience to assess the biological effectiveness of the use of chemicals against alternariosis or brown spot (*Alternaria alternata* (Fr.) Keissl.) was also carried out in the pomegranate gardens of the Goranboy region. The fungicides used in the studies were: 0.4% Selphate (37.5% copper oxychloride + 16% zineb), 0.05% Azoxifene (20% azoxystrobin + 12.5% difenoconazole), 0.05% Conazole (25% difenoconazole) and 0.3% P-oxiride (50% copper oxychloride).

Biological effectiveness was determined by the reduction in the development of alternariosis or brown spot (*Alternaria alternata* (Fr.) Keissl.) on the treated variants relative to the control (Garibova, Lekomtseva, 2005).

For treatment with these preparations, areas of the garden were selected where bushes of two varieties of pomegranate grow – "Kyrmyzy Kabukh" and "Pink Gulosha". Both varieties are less resistant to brown spot. To apply each drug, 2 rows of bushes were used on these two cultivars. It should be noted that in the fight against diseases of pomegranate bushes, chemical plant protection products are traditionally used and are considered economically feasible. These fungicides are still used in a wide range for the prevention and protection of plants. However, the use of toxic chemicals poisons and destroys components of biocenoses, such as soil, soil organisms, pollinators and other beneficial organisms. To preserve biocenoses and reduce the pesticide load, more and more preference is given to biological preparations. In this experiment, 4 drugs were used: 0.4% Selphate, 0.05% Azoxifene, 0.05% Conazole and 0.3% P-oxiride. Plant treatment was carried out in 3 main phases: before and after flowering, as well as the fruiting period. Tests of these drugs were carried out on pomegranate orchards in the Goranboy region (western part of the country) in 2018–2023 years.

Chemical protection measures in the field were carried out using the ZUBR PV 20.47.K1 sprayer. After the first chemical spraying, repeated sprayings were carried out every 14 days, depending on the development and spread of the disease.

RESEARCH RESULTS AND DISCUSSION

During 2018–2023, as a result of research conducted by L.A. Huseynova in pomegranate orchards of large industrial importance located in the western part of Azerbaijan, it was established that fungal diseases are the cause of a decrease in the quantitative and qualitative indicators of the pomegranate harvest.

Among the fungal diseases of pomegranate bushes, alternariosis or brown spot (*Alternaria alternata* (Fr.)

Keissl.), which occurs especially in conditions of low temperature and high humidity with large amounts of precipitation, is quite harmful. To this end, we determined the spread and development of this disease in the western regions of Azerbaijan during 2018–2023 (Table 1).

As can be seen from the table, during the research we conducted in the industrial pomegranate orchards of the western part of Azerbaijan in 2018–2020 in all three regions, the incidence of pomegranate bushes by alternariosis or brown spot (*Alternaria alternata* (Fr.) Keissl.) was the highest in both cultivars in the Goranboy region, and the smallest in the Kazakh region. Analysis of the results obtained in 2018–2020 research showed that the spread and development of the disease during this period is increasing in all areas. During the years of research, a moderate prevalence of the disease was established.

Accordingly, we also established the spread and development of alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) in the western part of the country in 2021–2023 (Table 2).

As can be seen from the table, in the 2021–2023 research years, Alternariosis or brown spot (*Alternaria alternata* (Fr.) Keissl.) on pomegranate bushes was most often found in the Krmyzy kabukh pomegranate cultivar in the Goranboy region. Analysis of the prevalence and intensity of development of alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) shows that in the western regions of Azerbaijan over all

Table 1. Accounting for the prevalence and development of alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) in the conditions of the Ganja-Kazakh geographical zone (western part of the country) of Azerbaijan (2018–2020).

Western regions of Azerbaijan	Pomegranate cultivars	Affected organs of pomegranate	2018 year		2019 year		2020 year	
			P [%]	R [%]	P [%]	R [%]	P [%]	R [%]
Goranboy	Kyrmyzy Kabukh	leaves	25.0	14.5	27.9	15.6	34.6	19.7
		fruits	19.7	13.0	20.2	13.6	21.1	14.0
	Pink Gulosha	leaves	24.6	12.8	25.2	13.1	26.9	14.4
		fruits	18.8	12.0	19.5	13.0	20.1	13.6
Shamkir	Kyrmyzy Kabukh	leaves	18.8	12.9	19.0	13.0	19.9	13.2
		fruits	16.3	9.9	16.7	10.5	17.5	11.2
	Pink Gulosha	leaves	16.1	9.7	16.4	9.9	17.1	10.2
		fruits	16.0	8.9	16.2	9.4	16.3	9.5
Kazakh	Kyrmyzy Kabukh	leaves	15.8	7.9	16.4	8.9	16.9	9.8
		fruits	16.0	9.5	16.3	9.7	16.4	10.0
	Pink Gulosha	leaves	15.0	11.9	15.4	10.6	15.7	10.9
		fruits	15.6	9.9	15.8	10.3	15.9	10.7

Note: P – disease prevalence [%]; R – intensity of disease development [%]

Table 2. Distribution and intensity of development of alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) in various western regions of Azerbaijan (2021–2023).

Western regions of Azerbaijan	Pomegranate cultivars	Affected organs of pomegranate	2021year		2022 year		2023 year	
			P [%]	R [%]	P [%]	R [%]	P [%]	R [%]
Goranboy	Kyrmyzy Kabukh	leaves	38.0	19.2	38.6	19.7	38.9	19.9
		fruits	37.5	18.1	37.7	18.3	37.8	18.9
	Pink Gulosha	leaves	35.7	16.9	36.8	17.1	37.7	17.8
		fruits	34.5	15.9	35.6	16.0	36.6	16.5
Shamkir	Kyrmyzy Kabukh	leaves	23.5	12.9	24.4	13.3	25.6	14.0
		fruits	20.1	12.0	20.8	12.0	21.0	12.7
	Pink Gulosha	leaves	19.9	11.9	20.4	12.5	20.9	12.7
		fruits	19.0	12.4	20.2	12.3	20.5	12.5
Kazakh	Kyrmyzy Kabukh	leaves	17.7	12.0	19.0	12.5	19.9	12.6
		fruits	16.9	10.7	17.5	11.8	18.5	11.9
	Pink Gulosha	leaves	16.7	10.5	17.4	11.3	18.0	11.8
		fruits	16.5	9.9	16.9	10.1	17.1	10.7

Note: P – disease prevalence [%]; R – intensity of disease development [%]

three years of research, the disease was more often found on leaves, less often on fruits. It should also be noted that agrometeorological factors have a great influence on the distribution and intensity of the development of alternariosis or brown spot. During the years of the study, the lowest prevalence of the disease was observed in the Kazakh region. In addition, pomegranate cultivars are not equally susceptible to alternariosis.

Low temperatures and prolonged frequent rains in early spring and mid-summer in 2018–2023 contributed to the intensive spread and development of the disease in the western regions of Azerbaijan. Damage to pomegranate fruits by Alternaria brown spot (*Alternaria alternata* (Fr.) Keissl.) in 2018–2023 differed only in certain years in the gardens of the western part of Azerbaijan.

Thus, in the indicated years of research, the air temperature was below 20 °C, and the relative air humidity was extremely high (80–90%).

As can be seen from the table, in all western regions where research was carried out in 2021–2023, the most infected with alternariosis or brown spot (*Alternaria alternata* (Fr.) Keissl.) cultivar is Kyrmyzy Kabukh, the least is the cultivar Pink Gulosha. Thus, during route observations carried out in the Kazakh region, it was found that alternariosis is less common in the leaves and fruits of both pomegranate cultivars. Thus, during years of heavy rains in the spring-summer season, alternariosis is widespread in pomegranate orchards in the western part of Azerbaijan and causes greater damage to pomegranate production.

In addition to field research of the phytopathogenic fungus *Alternaria alternata* (Fr.) Keissl., in 2021–2023 the causative agent of alternariosis or brown spot of pomegranate bushes was studied in detail by L.A. Huseynova in laboratory conditions.

Fungi of the genus *Alternaria* are widely represented in nature by saprotrophic and phytopathogenic species. Saprotrophs develop on various organic substrates. The reservoir of fungi of the genus *Alternaria* are dying plants and plant debris from which the fungus enters the soil. Along with other fungi, fungi of the genus *Alternaria* take part in the decomposition and mineralization of plant residues. This is facilitated by a huge complex of enzymes found in saprotrophic *Alternaria* (Muller, Leffler, 1995).

The rich enzyme apparatus of the fungus provides a wide range of adaptability and the ability to exist in fairly diverse conditions. This is also favored by the easy dispersal of spores by wind (anemochory) (Dyakov, 2001).

Some saprotrophic species, such as *Alternaria alternata* (Fr.) Keissl. with severe weakening of plants (especially pomegranate bushes) they can exhibit parasitic properties. They first settle on old leaves, and from them they move to young leaves, ovaries and fruits.

Alternaria alternata (Fr.) Keissl. – an imperfect fungus that develops on many plant substrates and in soil as a

Table 3. The influence of fungicides on the spread and development of alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) (2021–2023).

Fungicides	Pomegranate cultivars	Affected organs of pomegranate	2021 year			2022 year			2023 year		
			P [%]	R [%]	BE [%]	P [%]	R [%]	BE [%]	P [%]	R [%]	BE [%]
Azoxifene	Kyrmyzy Kabukh	leaves	25.5	15.7	59.0	25.0	14.8	61.2	23.7	12.5	68.4
		fruits	21.9	11.7	68.1	21.0	11.1	71.2	20.8	11.0	72.0
	Pink Gulosha	leaves	20.7	11.5	66.1	20.5	11.4	72.1	20.0	11.3	74.2
		fruits	23.0	12.1	64.4	22.6	11.5	68.0	22.1	11.1	70.0
Selphate	Kyrmyzy Kabukh	leaves	19.3	11.0	71.0	17.7	9.9	74.0	17.0	9.1	77.0
		fruits	15.5	7.5	80.0	15.2	7.1	82.0	15.1	7.0	82.0
	Pink Gulosha	leaves	14.3	6.9	80.0	14.0	6.6	84.0	13.7	6.0	86.3
		fruits	13.9	6.4	81.2	13.6	6.1	83.0	13.3	6.0	84.0
Conazole	Kyrmyzy Kabukh	leaves	19.9	10.9	71.2	19.1	10.8	72.0	19.0	11.0	72.2
		fruits	21.8	13.6	63.0	20.9	12.9	67.0	20.0	12.2	69.0
	Pink Gulosha	leaves	19.9	11.9	65.0	19.0	11.0	73.2	18.8	10.9	75.1
		fruits	19.2	11.8	65.3	18.9	11.3	69.0	18.0	10.6	71.1
P-oxiride	Kyrmyzy Kabukh	leaves	21.0	13.2	65.1	20.7	12.1	68.2	20.2	11.9	70.0
		fruits	23.3	14.0	62.0	22.2	13.3	66.0	21.9	12.0	69.1
	Pink Gulosha	leaves	18.9	11.2	67.0	18.3	11.0	73.2	17.9	10.9	75.1
		fruits	17.7	10.9	68.0	17.5	10.6	71.0	17.1	10.5	71.3
Control	Kyrmyzy Kabukh	leaves	67.7	37.8	0	68.3	38.1	0	70.0	39.5	0
		fruits	66.9	36.6	0	67.5	38.6	0	69.8	38.9	0
	Pink Gulosha	leaves	65.7	33.9	0	69.9	41.0	0	70.1	43.8	0
		fruits	63.2	34.0	0	65.1	35.9	0	66.9	36.7	0

Note: P – disease prevalence [%]; R – intensity of disease development [%]; BE – biological effectiveness [%]

saprophyte. Parasitizes various plants. *Alternaria alternata* (Fr.) Keissl. cosmopolitan, widespread everywhere.

Analyzes of literature data (Garibova, Lekomtseva, 2005; Dyakov et al., 2011)show that colonies of the fungus *Alternaria alternata* (Fr.) Keissl. black or olive-black, less often gray. The hyphae are colorless and may be olive or brownish. Thickness 3.0–6.0 microns. Conidiophores are solitary or in small groups, branched or simple, sinuous or straight, rarely geniculate. The color is pale, moderate olive, golden brown. The surface is smooth. The length of conidiophores is up to 50 μm, thickness 3.0–6.0 μm. Conidia of the fungus are formed in long, very often branched chains. The shape is obverse clavate, obverse pear, ovoid or elliptical. The color is pale to medium golden brown. The surface is smooth or finely warty. There are up to 8 transverse partitions. There are several longitudinal and oblique partitions. The size of fungal conidia is 20.0–63.0×9.0–18.0 microns.

From our research, it turned out that chemical measures give a good result in the fight against alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.). As already noted, against Alternaria brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.), we paid some attention to the development of a chemical method. For this purpose, the following fungicides were tested (Table 3).

During the study period, all these drugs demonstrated different, but statistically significant protective effects against weak and moderate degrees of brown spot development in terms of the prevalence and development of the disease on leaves and fruits. As can be seen from the table, the drug 0.4% Selphate gave the greatest biological effectiveness among the fungicides used for all three years.

CONCLUSIONS

In the last 5 years, there has been a trend of increasing harmfulness of alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.) in the western part of Azerbaijan. The leading reasons for the increasing severity of the disease at present are climatic factors. Low temperatures and prolonged frequent rains in early spring and mid-summer in 2018–2023 contributed to the intensive spread and development of the disease in the western regions of Azerbaijan. Damage to pomegranate fruits by Alternaria brown spot (*Alternaria alternata* (Fr.) Keissl.) in 2018–2023 differed only in certain years in the gardens of the western part of Azerbaijan. As our research results show, brown spot (*Alternaria alternata* (Fr.) Keissl.) mainly affected the leaves of pomegranate bushes. The time of spot formation is spring. During the first 2–3 weeks after the appearance of young leaves, spots of various shapes and sizes are observed. On the pomegranate cultivar "Kyrmyzy Kabukh", which is highly susceptible to the disease (in the Goranboy region), the percentage of affected leaves during 2018–2020 was ranged from 25.0 to 34.6, and in 2021–2023 from 38.0 to 38.9%.

The fungicides used in the studies were: 0.4% Selphate (37.5% copper oxychloride + 16% zineb), 0.05% Azoxifene (20% azoxystrobin + 12.5% difenoconazole), 0.05% Conazole (25% difenoconazole) and 0.3% P-oxiride (50% copper oxychloride). Biological effectiveness was determined by the reduction in the development of alternariosis or brown spot (*Alternaria alternata* (Fr.) Keissl.) on the treated variants relative to the control. From our research, it turned out that chemical measures give a good result in the fight against alternariosis or brown spot of pomegranate bushes (*Alternaria alternata* (Fr.) Keissl.). Among the fungicides we used in the 2021–2023 research years, 0.4% Selphate showed the greatest biological effectiveness.

REFERENCES

Beloshapkina O.O., 2017. Plant pathology. INFRA-M, 118 pp.

Carlilae M., Gooday G.W., Watkinson S.C., 2001. The Fungi. Academic Press, Second Edition, 293 pp.

Dankov V.V., et al., 2014. Subtropical crops. Moscow, Lan, 76 pp.

Deacon J.W., 2006. Fungal biology. Blackwell Publishing, Fourth edition, 59 pp.

Dyakov Y.T., 2001. General and molecular phytopathology. Society of Phytopathologists, 78 pp.

Dyakov Y.T., Bagirova S.F., Javakhia V.G., 2011. Fundamental phytopathology. Moscow, Kolos, 221 pp.

Garibova L.V., Lekomtseva S.N., 2005. Fundamentals of mycology: Morphology and systematics of fungi and fungi-like organisms. Association of scientific publications KMK, 124 pp.

Grekov S.P., 2002. Subtropical in mid-latitudes. Donetsk, AST-Stalker, 40 pp.

Guliyev F.A., Huseynova L.A., 2020. The main disease of pomegranate in chestnut (gray-brown) soils of Azerbaijan/ Ukraine, Kherson State Agrarian University. The impact of climate change on spatial development of Earth›s territories: implications and solutions, pp. 89-94.

Guliyev F.A., Huseynova L.A., 2021. Pomegranate moth is the most dangerous pest of pomegranate bushes in the conditions of the Western part of Azerbaijan. Academy of Agricultural and Forestry Sciences Gheorghe Ionescu – Şişeşti (AAFS), Romania, Romanian Journal of Horticulture, 2: 63-70.

Huseynova L.A., 2021a. Mycoses of pomegranate bushes in the western part of Azerbaijan. Institute of Plant Protection of the Republic of Belarus, scientific and practical journal Agriculture and Plant Growing, 3(136): 37-41.

Huseynova L.A., 2021b. Necrosis of leaves and fruits of pomegranate bushes in the western part of Azerbaijan. Bulletin of the Belarusian State Agricultural Academy, 3: 61-66.

Huseynova L.A., 2022a. Phyllosticosis or brown spotting of pomegranate leaves in the western part of Azerbaijan. pp. 21-25. X International Scientific and Practical Conference "Science and Education in the Modern World: Challenges of the 21st Century", Kazakhstan.

Huseynova L.A., 2022b. The susceptibility of various varieties of pomegranate to anthracnose or scab in the conditions of the western part of Azerbaijan. Russian State Agrarian University of Moscow Agricultural Academy named after K.A. Timir-

yazev, Abstracts of the International Scientific Conference "Problems of Selection-2022", Moscow, p. 110.
Kopylov V.I., Nikolenko V.V., Litvinova T.V., 2019. Subtropical crops. Moscow, Lan, 224 pp.
Maheshwari R., 2005. Fungi: Experimental Methods in Biology. Boca Raton, CRC Press, 103 pp.
Muller E., Leffler V., 1995. Mycology. Mir, 83 pp.
Popkova K.V., 2005. General phytopathology. Drofa, 49 pp.
Shkalikov V.A., 2001. Workshop on agricultural phytopathology. Kolos, 53 pp.
Spooner B., Roberts P., 2005. Fungi. HarperCollins Publishing, 137 pp.

Author	ORCID
Lala A. Huseynova	0000-0003-0687-0608

received 29 November 2023
reviewed 8 July 2024
accepted 10 September 2024

Author declares no conflict of interest.