Difenoconazole-based fungicides for orchard protection

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Abstract. A comparative assessment of the effectiveness of 4 difenoconazole-based fungicides in the fight against apple scab in the Krasnodar region and the Rostov Region for several years has been carried out. The preparations Sercadis Plus, SC were applicated at a rate of application of 1.2 l/ha; Embrelia, SC – 1.5 l/ha; Cidely Top, DC – 0.7 l/ha and Tersel, WG – 2.5 kg/ha three times, against different infectious backgrounds, starting with the "pink bud" phenophase (the end of flowering stage). The following apple cultivars were used: Idared, Champion and Golden Delicious. Research has shown that all studied fungicides significantly reduced the scab infestation of apple leaves and fruits. This resulted in obtaining additional yield in the range of 12.6-46.0%. The fruit grade was high after the treatments: 93.0-100% in the Krasnodar region and 81.5-91.5% in the Rostov Region, while in the nil treatment the percentages of standard products were 68.5% and 44.6%, respectively. According to the toxic load indicator, difenoconazole-based fungicides, such as Embrelia, SC (11.6 LD50 per hectare), were less dangerous for the fruit cenosis.

1 Introduction

In areas of the intensive fruit growing, fungicides from many chemical classes with different mechanisms of action are applicated to fight apple diseases. The scientifically substantiated rotation of pesticides reduces the likelihood of resistance formation and does not lead to the massive development of the disease, which is especially relevant for the scab pathogen [1,2]. An important tactical technique is the application of combined preparations [3,4]. For a long time, the treatment of pome fruits with triazoles, especially with difenoconazole-based triazoles (Skor, EC), was very successful. Many researchers believe that the main reason for the decrease in the effectiveness of preparations that inhibit ergosterol synthesis is repeated and uncontrolled treatments of orchards, which led to a decrease in the sensitivity of the phytopathogen [5-10]. An undoubted success was the discovery of strobilurins, due to which protective measures became ecologically oriented.

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Profitability, productivity and marketability were increased, as well as preservation capacity of the grown fruits. The growth of young shoots increased by 41-45%, the aging of the leaf apparatus slowed down due to an increase in photosynthetic activity and growth processes. However, due to the resistance to strobilurins, observed in many countries [11-15], they began to be used to a greater extent as a component for the combination of preparations. The range of fungicides was supplemented by low-toxic preparations with new active substances from carboxamides and anilinopyrimidines: Luna Tranquility, SC (125 + 375 g/l) based on a combination of *pyrimethanil* and *fluopyram*; Fontelis, SC (200 g/l, *penthiopyrad*), as well as a combination of *difenoconazole* and *flutriafol* Medea, ME (50 + 30 g/l). Carboxamides have a wide spectrum of fungicidal activity, are slightly toxic to warm-blooded animals and humans, and the environment. Their mechanism of action differs from triazoles, which inhibit ergosterol synthesis. *Fluxapyroxad*, *isopyrazam* and *cyflufenamid*, as representatives of carboxamides, act on the respiratory process of fungi by inhibiting the enzyme succinate dehydrogenase (SDH) and disrupt the electron transport in the complex II-oxidation of succinic acid (succinate) to fumarate in the mitochondria of fungi and disrupt cellular energy metabolism [16]. Thus, the growth of the fungus mycelium in the intercellular space and the formation of spores are suppressed. They are distributed differently throughout the tissues of plants: *fluxapyroxad* – systemically, *isopyrazam* – locally-systemically, and *cyflufenamid*, along with its systemic action, have deep translaminar penetration into tissues and prolonged residual activity for up to 30-40 days. Therefore, the selection of fungicides with high effectiveness in the fight against apple scab and less hazardous to the environment remains highly relevant. The object of this paper is a comparative assessment of the effectiveness of difenoconazole-based combined fungicides for protection of the apple trees against scab: Embrelia, SC; Sercadis Plus, SC and Cidely Top, DC and their toxic assessment for the fruit cenosis

2 Materials and methods

The experiments were carried out in the fruit-growing regions of the country on apple-tree plantings of different ages with agricultural technology generally accepted for the region. In the Krasnodar Krai – 14-16-*year-old* Idared plantings, 6-year-old Champion plantings, in the Rostov Region 15-18-year-old Idared plantings, 6-year-old Golden Delicious plantings. Fungicides: Sercadis Plus, SC (75 g/l fluxapyroxad + 50 g/l difenoconazole), a rate of application of 1.2 l/ha; Embrelia, SC (100 g/l isopyrazam + 40 g/l difenoconazole), a rate of application of 1.5 l/ha and Cidely Top, DC (125 g/l difenoconazole + 15 g/l cyflufenamid), a rate of application 0.7 l/ha were applicated three times by spraying vegetative plants, starting with the “pink bud” phenophase (the end of flowering stage) up to the “Fruits” phenophase (from the stage, when the fruit size is like the size of a walnut, to the stage of fruit formation and ripening). The experiments were carried out for several years. Standard: Tersel, WG (120 g/l boscalid + 40 g/l pyraclostrobin) at the rate of application of 2.5 kg/ha (3 times). To control, the nil treatment was used. The flow rate of the working fluid was 800-1000 l/ha, the spraying device was the powered backpack sprayer Hardy MRY-3. The toxic load (environmental hazard of the fungicide) was determined by the active substance applied per unit area of the cultivated crop during its treatment with the recommended rate of application and the degree of toxicity to warm-blooded animals.

3 Results and discussion

Research in the Krasnodar region was carried out against mild to moderate infectious background of scab development in 2013-2016. As the results in Fig. 1 indicate, the

effectiveness of the preparations applicated in the fight against apple scab was high and varied slightly depending on the experiment: to the leaves – from 83.3% to 93.6-99.2%; to the fruits in the crown of trees – from 90.3% to 98.8%; to the fruits of cut yield – from 89.2% to 100%.

The application of fungicides in orchards in the fight against scab resulted in preserving the apple yield; the differences in variants were within the limits of experimental error. Crop yield was: 12,6% (Sercadis Plus, SC), 15,0% (Embrelia, SC); 18,5% (Cidely Top, DC) and 16,0% (Tersel, WG).

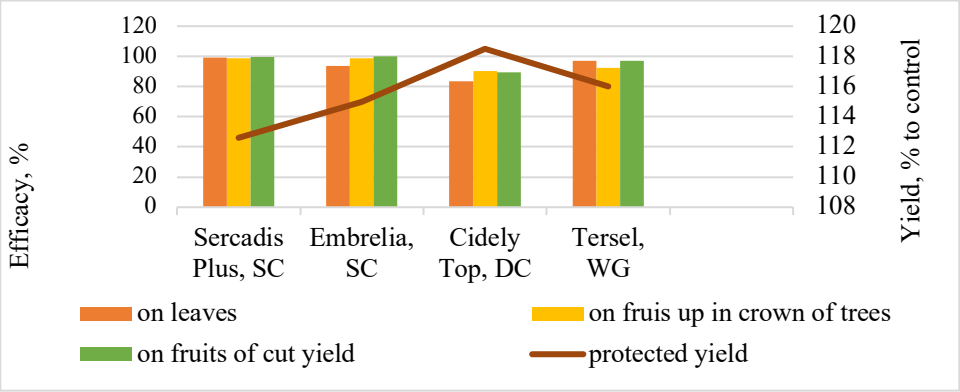

Fig.1. A comparative assessment of the effectiveness of difenoconazole-based fungicides in the fight against apple scab in the Krasnodar region in 2013-2016.

The scab development in the Rostov Region in 2013-2017 was moderate and fairly high: 25,4-51,2% (leaves); 14,6-47,2% (fruits in the crown of trees).

The studied preparations protected the leaves from scab up to 76.3%, the fruits up to 84.8% in the crown of trees and the fruits of cut yield up to 75.0% (Fig. 2). Against such an infectious background, three-fold treatments of the apple tree in the fight against apple scab guaranteed the highest crop yield: 146,0% (Sercadis Plus, SC); 136,1% (Embrelia SC); 130,7% (Cidely Top, DC) and 129,5% (Tersel, WG).

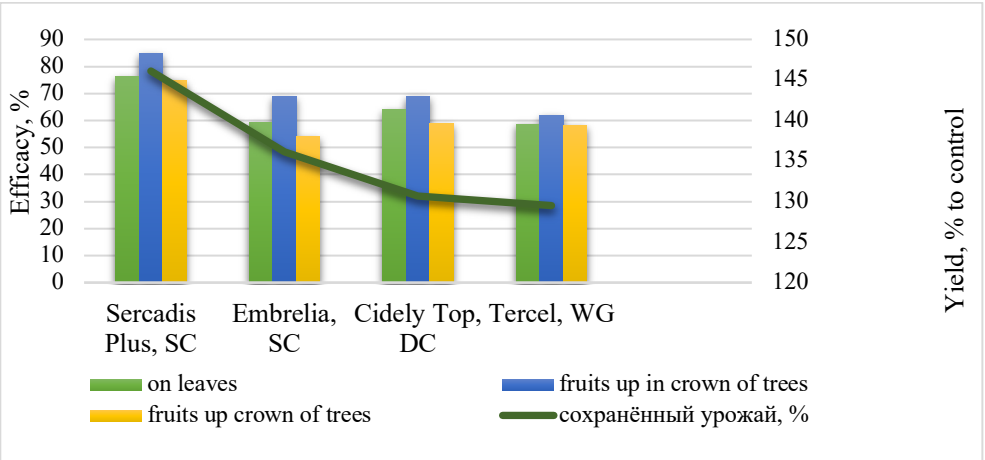

Fig.2. A comparative assessment of the effectiveness of difenoconazole-based fungicides in the fight against apple scab in the Rostov Region in 2013-2017.

The studied preparations protected the leaves from scab up to 76.3%, the fruits up to 84.8% in the crown of trees and the fruits of cut yield up to 75.0% (Fig. 2). Against such an infectious background, three-fold treatments of the apple tree in the fight against apple scab guaranteed the highest crop yield: 146,0% (Sercadis Plus, SC); 136,1% (Embrelia SC); 130,7% (Cidely Top, DC) and 129,5% (Tersel, WG).

The application of fungicides had a positive effect on the fruit grade of grown fruits (table 1). In the Krasnodar region, almost all fruits after fungicide treatments were standard: 100% (Sercadis Plus, SC), 99.0% (Cidely Top, DC); 90.0% (Embrelia, SC) and 93.0% (Tersel, WG), in the nil treatment there were 68.5% of standard fruits.

Table 1. Effect of difenoconazole-based fungicides on apple fruit grade

Preparation	Rate of application [l, kg/ha]	Standard products, %	
		Krasnodar Krai	Rostov Region
Sercadis Plus, SC	1.2	100	91.5
Embrelia, SC	1.5	99.0	87.5
Cidely Top, DC	0.7	99.2	81.5
Tersel, WG	2.5	98.7	82.2
Control (nil treatment)	-	68.5	44.6

In the Rostov region, the crop yield of standard fruits in the variant of fungicide application was high (81.5-91.5%), while in the nil treatment variant the share of standard fruits was only 44.6%. All of this reflects the high biological and economic effectiveness of these fungicides in orchards against scab.

Difenoconazole-based fungicides in terms of the toxic load are less dangerous for the fruit cenosis, the lowest toxic load indicator was obtained using Embrelia SC (11.6 LD50 per hectare), when using Cidely Top, DC this indicator was 62.3 LD50 per hectare, and Sercadis Plus, SC – 86.3 LD50 per hectare, while the toxic load during the treatment of an apple orchard with Tersel, WG was much higher (1020 LD50 per hectare).

4 Conclusion

The studied difenoconazole-based fungicides (Sercadis Plus, SC; Embrelia, SC; Cidely Top, DC) in the main fruit-growing regions of the country and against different infectious backgrounds of scab development significantly reduced the development of the disease on the leaves and fruits of the apple trees to economically imperceptible losses, guaranteeing a high crop yield of preserved fruit crop up to 46.0%. These preparations have less impact on the environment, especially the preparation Embrelia, SC, which has the lowest toxic load indicator for the fruit cenosis (11.6 LD50 per hectare). This indicator is slightly higher after the application of the fungicides Cidely Top, DC and Sercadis Plus, SC (62.3 and 86.3 LD50 per hectare, respectively), and is much higher when treating the apple orchard with Tersel, WG (1020 LD50 per hectare).

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