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The effect of plant growth regulators on the growth, development, and incidence of fungal diseases of black currant in conditions of the city of Moscow

V.V. Antonenko[1,*], *A.V.* Zubkov[2], and *A.V.* Dovgilevich[1]

[1]Agroecology of Pesticides and Agrochemicals, RGAU-MAA named after K. A. Timiryazev, Moscow, Russia
[2]Department of Horticulture, Viticulture and Winemaking of K. A. Timiryazev Russian State Agricultural University Moscow Agricultural Academy, Moscow, Russia

Abstract. Small-plot field experiments were laid on the territory of the Educational and Experimental Farm of the FSBEI HE RSAU-MAA named after K.A. Timiryazev on the territory of the city of Moscow. The following plant growth regulators were used in the experiments: Zavyaz, KRP (5.5 g/l gibberellic acid sodium salts); Obereg, R (0.15 g/l arachidonic acid), Zircon, R (0.1 g/l hydroxycinnamic acids), Epin-Extra, R (0.025 g/l 24-epibrassinolide). As part of the study, for two years, young blackcurrant plantings of three varieties with different maturation periods were treated with plant growth regulators. During the growing season, plant growth and development were recorded, the development of fungal diseases was recorded – powdery mildew (*Sphaerotheca mors-uvae*) and blister rust (*Cronartium ribicola*). Accounting for the yield of berries in various experiment options was carried out in comparison with the control version. The results of the study showed that the double use of growth regulators Zavyaz, KRP, Obereg, R, Zircon, R, and Epin-Extra, R positively influenced the formation of growth of black currant shoots and significantly reduced the development of fungal disease - powdery mildew on the leaves and berries of this crop.

1 Introduction

Plant growth regulators are approved for use on many crops [1-3].

Many of the growth regulators used, in addition to their direct effect on growth processes in plants, can have a positive effect on plant immunity, increasing the ability of cultivated plants to resist pathogens [1-6]. Plant growth regulators with an immunostimulating effect are also allowed to be used on berry crops. Such substances can reduce the incidence of diseases, increase the resistance of plants to abiotic stresses, as well as increase crop yield and its quality.

At the moment, growth regulators from various chemical groups with different ways of

[*] Corresponding author: antonenko_viktor@mail.ru

influencing the culture have been registered on berry crops. The property of individual growth regulators to increase plant immunity is important for use on berry crops, since the use of pesticides on them is limited [7-14].

On black currant, the use of chemical fungicides against fungal diseases is allowed only before flowering or after harvesting [7-9]. For this reason, the use of growth regulators that are not dangerous to human health, capable of having a positive effect on plant immunity and improving crop formation, is of particular interest in this crop. The use of resistant varieties is important for the organization of proper disease control.

A significant part of the fungal diseases developing on black currant begins to affect this crop during the period of berry growth and ripening, when the use of chemical fungicides for safety purposes is not allowed. For this reason, the use of environmentally friendly growth regulators that reduce the development of fungal diseases is an important element of protecting this crop.

During the initial growing season, such a common disease as powdery mildew (*Sphaerotheca mors-uvae*) has a significant effect on the growth of shoots and the formation of a berry yield in black currant, since it can significantly reduce the development of young shoots and affect the forming berries and worsen their quality. The strong development of such a common fungal disease as blister rust (*Cronartium ribicola*) can also significantly reduce the development of shoots and reduce the yield of black currant berries. For this reason, studying the possibility of reducing the development of this disease through the use of plant growth regulators, without the use of fungicides, is a promising solution to increase the productivity of this crop.

2 Materials and Methods

During the growing seasons of 2023-2024 on the territory of the Educational and Experimental farm of the FSBEI HE RSAU-MAA named after K.A. Timiryazev in the city of Moscow small-plot tests were conducted. The soil in the experimental plots is sod-podzolic, medium loamy, with pH = 6.2, humus – 2.2%. In one experiment option, 16 black currant plants were used, the repetition was fourfold, the location was randomized. Plants of the 2nd year of planting were used, planted according to the scheme: 1.2x0.3 m. 3 varieties of black currant were used in the experiments: Selechenskaya -2, Nezhdanchik, and Nara (medium-ripe in terms of maturity, included in the State Register of the Russian Federation for the 1st Soil and Climatic zone of the Russian Federation).

The application of the studied growth regulators was carried out in the recommended consumption rates, working solutions were used for their intended purpose within one hour after preparation, subject to all regulations [7, 9].

Plant growth regulators were used in the following consumption rates: Zavyaz, KRP (5.5 g/l gibberellic acid sodium salts) at a rate of 1.2 l/ha − double treatment (spraying: 1st - in the budding phase, 2nd - in the phase of green ovaries); Obereg, R (0.15 g/l arachidonic acid) − normally 60 ml/ha, double treatment (1st - in the phase of the beginning of flowering; 2nd - 30 days after the first spraying); Zircon, R (0.1 g/l of hydroxycinnamic acids)- spraying in the budding phase; Epin-Extra, R (0.025 g/l 24-epibrassinolide) normally 1 ml/5 liters of water − double treatment (spraying: 1st - in the budding phase, 2nd - in the phase of green ovaries) [7]. Each variety had an option without treatment with plant growth regulators − control.

Records of the development of fungal diseases were carried out every 10 days after the treatments with the studied preparations throughout the growing season. Accouting of the disease infestation of leaves and berries was carried out on a 5-point phytopathological scale with further calculation of the biological efficacy of preparations in each experiment option relative to the control option according to the methodological instructions.

3 Research results

The use of growth regulators in blackcurrant plantings is widely studied by many researchers [1-3, 6, 10-20]. All plant growth regulators used in the study are recommended by manufacturers as preparations that increase the yield and quality of black currant berries.

Plant growth regulators Obereg, R, Zircon, R, and Epin-Extra, R on plants help to increase the immunity of black currant to fungal diseases, increase the ability of plants to resist adverse environmental conditions [1-3, 6, 11-13].

It is known that the growth regulator Zircon, R enhances the respiration processes in plants and has a positive effect on growth processes [1-3, 11-14].

Recommended for use as a growth regulator, Zavyaz, KRP promotes stimulation of ovary formation and reduction of ovary prolapse, maturation acceleration. It is also known that the active ingredient of the growth regulator Zavyaz, KRP – gibberellic acid is able to enhance shoot formation [1-4].

Plant growth regulator Epin-Extra, R causes activation of growth and shaping processes, is able to increase the set capacity of berries, increase resistance to adverse environmental factors and disease damage, increases the yield and quality of black currant products [1-4, 7].

According to the results of the study, it was noted that all the studied growth regulators increased the formation of growth shoots and their length under experimental conditions.

During two years of testing on the Selechenskaya-2 variety, a significant effect of growth regulators on reducing the development of fungal diseases − powdery mildew and blister rust was recorded. Thus, in the option with the use of the growth regulator Zavyaz, FRP the decrease in the development of powdery mildew was 35.7% on leaves and 46.2% on berries, the development of blister rust was reduced by this preparation by 36.4%. The growth regulator Zircon, R also demonstrated a significant decrease in the development of powdery mildew: by 55.8% on leaves and by 60.7% on berries, the decrease in the development of blister rust was 50%. The use of the growth regulator Epin-Extra, R reduced the development of powdery mildew by 46.9% on the leaf surface and by 55.4% on berries (Table 1).

On the Selechenskaya-2 variety, the best result in reducing the development of fungal diseases was demonstrated by the drug Obereg, R: the decrease in the development of powdery mildew was 62.3% on leaves and 66.1% on berries. The development of blister rust was 54.5% lower in the option using this growth regulator (Table 1).

It should be noted that in the control variant, the significant development of powdery mildew on berries reduced the weight and size of berries and caused their premature fall. Thus, the use of the studied growth regulators contributed to obtaining an increase in yield both through direct action on plants and by reducing the development of fungal diseases.

A significant increase in yield by weight of berries on the Selechenskaya-2 variety was 79% in the option with the use of Zircon, R, 51.9% − in the option with the Obereg, R, in the option with the use of Zavyaz, KRP − 50.8%, the preparation Epin-Extra, R − 25.5% (Table 1).

The best results in the formation of shoots of growth over two years were demonstrated by the growth regulator Epin-Extra, R, an increase in the number of shoots formed during the ripening of berries on the Selechenskaya-2 variety was 90.4%. The growth regulators Zavyaz, KRP and Zircon, R, increased the formation of shoots at a close level – by 78.1% and 77.4%, respectively (Table 1).

In the Selechenskaya-2 variety, the effect on the length of the shoots formed during the two years of the study, the applied growth regulators Zavyaz, KRP and Zircon, R had a close level: 52.4−64.3% relative to the control (Table 1).

The growth regulators Epin-Extra, R and Obereg, R increased the length of shoots by 52.4 and 57.1% relative to the control, respectively (Table 1).

Table 1. Results of application of plant growth regulators on black currant of the Selechenskaya variety-2, 2023-2024.

Experiment option	Number of continuance shoots, pcs +% relative to control	Average length of continuance shoots, cm, +% relative to control	Average berry yield, g/bush, +% relative to control	Reduction of powdery mildew development relative to control, %		Reducing the development of blister rust relative to control, %
				On leaves	On berries	On leaves
Zavyaz, KRP	26 (+78,1%)	20.7 (+64.3%)	189.4 (+50.8%)	35.7	46.2	36.4
Zircon, R	25.9 (+77,4%)	19.2 (+52.4%)	225 (+79%)	55.8	60.7	50
Epin-Extra, R	27.8 (+90,4)	19.8 (+57.1)	157.7 (+25.5%)	46.9	55.4	22.7
Obereg, R	20.2 (+38.4)	20.1 (+59.5)	191.1 (+51.9%)	62.3	66.1	54.5
Control (without treatment)	14.6	12.6	125.7	- (R*=26%)	- (R=28%)	- (R=4,4%)
LSD 05	1.10	1.21	3.42	0.82	0.30	

The growth regulators tested on the Nezhdanchik variety also significantly reduced the development of fungal diseases. The lesion of the leaves of this variety with powdery mildew in the control was 23% and berries − 21%, the development of blister rust in this variety reached 9.4%.

During two-year tests, this variety of black currant was most severely affected by blister rust, with a disease development rate of R =9.4% (records in the last decade of July). The decrease in the development of blister rust in options using the drugs Zircon, R and Obereg, R was the most effective and amounted to 46.8% and 51.1%, respectively, over two years (Table 2). The decrease in the development of this fungal disease in options with the use of growth regulators Zavyaz, KRP and Epin-Extra, R was 40.4% for each of these options (Table 2).

A decrease in the development of powdery mildew on the Nezhdanchik variety was recorded for growth regulators Obereg, R and Zircon, R at a high level: a significant decrease in the development of powdery mildew in these options was 52.2-49.6% on leaves and 56.4-43.8% on berries, respectively, for two experiment options. The use of growth regulators Zavuaz, KRP and Epin-Extra, R reduced the development of powdery mildew by 32.6-44.3% on the leaf surface and by 37.1-37.6% on berries, respectively (Table 2).

The use of growth regulators on Nezhdanchik black currant increased the formation of continuance shoots by 28.9% in the option using Zircon, R by 31.3% − in the option with Obereg, R, in the option using Epin-Extra, R - by 17.2% (Table 2).

The best results, in this variety, in increasing the number of shoots over two years, were demonstrated by the preparation Zavyaz, KRP, which showed a result of 70.3%. This preparation also demonstrated the largest increase in the length of continuance shoots, which for the Nezhdanchik variety was 117.2% (Table 2).

On the Nezhdanchik variety, during two years of research, an increase in growth shoots was recorded in options using growth regulators: for the preparation Zircon, R − 48.3%, for the preparation Epin-Extra, R − 14.7%, for the preparation Obereg, R − 74.1%, relative to control (Table 2).

A significant increase in yield by weight of berries on the Nezhdanchik variety was 31.2% in the option with the use of Zircon, R, 38% − in the option with the Obereg, R, in the option with the use of Zavyaz, KRP − 26.6%, the preparation Epin-Extra, R − 33.6% (Table 2).

Table 2. The results of the application of plant growth regulators on black currant variety Nezhdanchik 2023-2024.

Experiment option	Number of continuance shoots, pcs +% relative to control	Average length of continuance shoots, cm, +% relative to control	Average berry yield g/bush, +% relative to control	Decrease in development of powdery mildew relative to control, %		Reducing the development of blister rust relative to control, %
				On leaves	On berries	On leaves
Zavyaz, KRP	21.8 (+70.3%)	25.2 (+117.2%)	139.3 (+26.6%)	32.6	37.1	40.4
Zircon, R	16.5 (+28.9%)	17.2 (+48.3%)	144.3 (+31.2%)	49.6	43.8	46.8
Epin-Extra, R	15 (+17.2%)	13.3 (+14.7%)	147 (+33.6%)	44.3	37.6	40.4
Obereg, R	16.8 (+31.3%)	20.2 (+74.1%)	151.8 (+38%)	52.2	56.4	51.1
Control (without treatment)	12.8	11.6	110	- (R*=23%)	- (R=21%)	- (R =9.4)
LSD 05	1.20	0.96	3.68	0.45	0.32	

In the conditions of 2023-2024, the black currant variety Nara turned out to be the least affected by powdery mildew (leaf surface damage) and blister rust. The development of blister rust on the leaf surface was 4.6%. The lesion of the leaves of this variety with powdery mildew in the control was 11.6% and berries - 21.8%. Plant growth regulators on this black currant variety also significantly reduced the development of fungal diseases (Table 3).

The decrease in the development of blister rust in options using the drugs Zircon, R and Obereg, R was the highest and amounted to 47.8% and 56.5%, respectively, over two years (Table 3). The decrease in the development of this fungal disease in options with the use of growth regulators Zavyaz, KRP and Epin-Extra, R was 30.4% and 43.5%, respectively, according to these options (Table 3).

At a fairly high level, a decrease in the development of powdery mildew on the Nara variety was recorded for the growth regulators Obereg, R and Zircon, R: a significant decrease in the development of powdery mildew in these options was 62.9-58.6% on leaves and 56.9-39.4% on berries, respectively, for two experiment options. The use of growth regulators Zavyaz, KRP and Epin-Extra, R reduced the development of powdery mildew by 47.4-46.6% on the leaf surface and by 32.1% on berries in both options (Table 3).

The use of growth regulators on black currant of the Nara variety increased the formation of continuance shoots in the option with the use of Epin Extra, R by 34.5%, by 61.8% − in the option with Obereg, R. The highest results in the number of formed continuance shoots were demonstrated by options using Zavyaz, KRP and Zircon, R: 87.3 and 89.1%, respectively (Table 3).

It should be noted that of all three varieties, the Nara variety differed in the least shoot-forming ability and the length of seasonal growth during the two years of the study. The best results in the length of shoots of growth were recorded in variants using Zavyaz, KRP and Obereg, R growth regulators, respectively, the increase in the length of shoots for these options was 75.4% and 83.6%. In the options with Zircon, R and Epin-Extra, R, the increase in the length of shoots was 11.5% and 21.3% (Table 3).

The best results for a reliable increase in yield by weight of berries on the Nara variety were obtained in the option using Zircon, R 27.4% and in the option using Zavyaz, KRP −

20.7%. In the option with the use of Obereg, R, the reliable yield increase was 16.5%, in the option with the use of Epin-Extra, R − 12.3% (Table 3).

Table 3. The results of the application of plant growth regulators on black currant of the Nara variety 2023-2024.

Experiment option	Number of continuance shoots, pcs, +% relative to control	Average length of continuance shoots, cm, +% relative to control	Average berry yield, g/bush, +% relative to control	Decrease in development powdery mildew relative to control, %		Reducing the development of blister rust relative to control, %
				On leaves	On berries	On leaves
Zavyaz, KRP	20.6 (+87.3%)	10.7 (+75.4%)	136.3 (+20.7%)	47.4	32.1	30.4
Zircon, R	20.8 (+89.1%)	7.4 (+21.3%)	143.8 (+27.4%)	58.6	39.4	47.8
Epin-Extra, R	14.8 (+34.5%)	6.6 (+8.2%)	126.8 (+12.3%)	46.6	32.1	43.5
Obereg, R	17.8 (+61.8%)	11.2 (+83.6%)	131.5 (+16.5%)	62.9	56.9	56.5
Control (without treatment)	11	6.1	112.9	- (R=11.6)	-(R=21.8)	- (R=4.6)
LSD 05	1.56	0.24	1.11	2.10	1.50	2.13

All the studied preparations significantly reduced the development of fungal diseases during two years of research on each of the studied varieties. The decrease in powdery mildew and blister rust in each option was significant according to statistical processing. All the studied growth regulators reduced the development of powdery mildew on black currant leaf surface with an efficiency of 32.6 to 62.9%, on berries: from 32.1 to 66.1% (Tables 1-3).

During two seasons of the study of the development of blister rust on black currant leaf surface, the preparations in question were reduced in the range from 22.7 to 56.5% (for three varieties of culture) (Tables 1-3).

According to the results obtained, it can be noted that the use of the growth regulator Obereg, R most contributed to reducing the development of fungal diseases such as blister rust and powdery growth, relative to other preparations. The effectiveness of reducing powdery mildew of leaves with the preparation Obereg, R on three different black currant varieties during two growing seasons ranged from 52.2 to 62.9%, on berries from 56.4 to 66.1% (Tables 1-3). The high ability of the plant growth regulator to protect and reduce the development of fungal diseases in experimental conditions can be explained by the fact that arachidonic acid in plants exhibits the properties of an immunostimulator that triggers protective mechanisms in plants.

It should be noted that in the control experiment options, where the growth regulators of the experimental black currant plants were not treated, a high degree of damage to the berries by powdery mildew caused premature fall of the harvest berries. It is also known that the strong development of powdery mildew on currants causes a decrease in the quality of berries, reduces their number and size. Also, the development of powdery mildew, which is observed in the first half of the growing season, can slow down the development of black currant shoots and leaf formation.

It can be assumed that the ability of individual plant growth regulators used in the study to increase plant immunity contributed to an increase in shoot formation, an increase in the area of the assimilating surface and an increase in yield.

According to the results of a two-factor analysis of variance, it was found that the amount of increase in the yield of black currant in options with the use of growth regulators largely depended on which black currant variety the preparation was used (Table 4). In each case, the yield increase based on the results of the use of growth regulators was significant (Tables 1-3). Thus, the studied plant growth regulators had varying degrees of influence on obtaining additional yield on various black currant varieties.

Table 4. Results of the effect of plant growth regulators on yield of black currants of three different varieties 2023-2024.

Experiment option	Selechenskaya-2 variety	Nezhdanchik variety	Average berry yield, g/bush, +% relative to control
	Average berry yield, g/bush		
Zavyaz, KRP	189.4	139.3	136.3
Zircon, R	225	144.3	143.8
Epin-Extra, R	157.7	147	126.8
Obereg, R	191.1	151.8	131.5
Control (without treatment)	125.7	110	112.9
		P-value	F-critical
	Factor A-variety	4.088	3.150
	Factor B-preparation	1.318	2.525
	Interaction of factors	3.371	2.097

Thus, the results of the study confirm the ability of the considered plant growth regulators to reduce the development of fungal diseases − powdery mildew and blister rust. It was found that the amount of berry yield increase for each growth regulator used was different for different black currant varieties. It can be noted that the greatest decrease in the development of fungal diseases was noted in the options with the use of the growth regulator Obereg, R.

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4 Conclusions

1. The use of plant growth regulators, Zavyaz, KRP, Obereg, R, Zircon, R, and Epin-Extra, R on currant plantings of three different varieties – Selechenskaya-2, Nezhdanchik, and Nara ensured a reliable increase in berry yield.
2. The use of plant growth regulators, Zavyaz, KRP, Obereg, R, Zircon, R, and Epin-Extra, R on currant plantings of three different varieties – Selechenskaya-2, Nezhdanchik, and Nara significantly reduced the development of fungal diseases – powdery mildew and blister rust.
3. The best result in reducing the development of fungal diseases was established in the experiment options using the plant growth regulator Obereg, R.
4. The tested plant growth regulators demonstrated a different amount of yield increase on various black currant varieties.

The data obtained as a result of the study prove the possibility of using plant growth regulators on black currant plantings to reduce the development of fungal diseases –

powdery mildew and blister rust. The use of pesticides on black currants, as on any berry crop, is significantly limited by the period from the beginning of berry formation to harvesting. On currant plantings, the use of growth regulators capable of increasing plant immunity and reducing the development of fungal diseases is a sought-after element in the technology of this crop cultivation. The study of the possibility of using growth regulators on berry crops allows, to a certain extent, to provide protection against fungal diseases, during a period when the use of pesticides is prohibited. Also, the use of preparations that positively affect the immunity of berry plants will reduce the pesticide load and ensure more environmentally friendly products. This topic is relevant and promising for further study.

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