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INFLUENCE OF THE GROWTH REGULATOR ON PLANT PRODUCTIVITY AND CROP QUALITY IN TWO REMONTANT RASPBERRY VARIETIES IN SOUTH-EAST OF KAZAKHSTAN

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Abstract :

The influence of retardants on the dynamics of development, productivity, physiological and biochemical parameters of two varieties of remontant raspberries, Bryanskoe divo and Polka was studied. Retardant treatment was performed two times during the period of the most intensive shoot growth with a 20-day interval. Significant inhibition of growth processes has been established when subminimal doses are treated with Reglon contact herbicide. The inhibitory effect of the retardant Tse-Tse-Tse across the whole range of studied parameters was lower, but it did not cause the expected activation of generative processes. The optimal parameters of the bushes and the optimization of physiological generative processes were noted when using the Sprayfert - Biostim combination containing, along with water-soluble and highly assimilable nitrogen, phosphorus and potassium substances with a hormonal-gibberrelin effect. An acceleration of the onset of ripening by 7 days and an increase in yield by 12% were achieved.

Keywords: remontant raspberries, variety, shoot, chlorophyll, growth stimulant, retardant.

Introduction :

Raspberry is the second most important berry crop after wild strawberries as in world production. However, at present, in the Republic of Kazakhstan, the areas of planted raspberry plantations have begun to exceed strawberries. In the Almaty region over the past three years, about 300 hectares of plantations have already been planted, with only remontant varieties.

Repairing varieties can significantly extend the harvest season of berries. They bear fruit not only in summer, but also in autumn, and the first crop can be obtained already a year after planting. Remontant raspberries make it possible to get good yields even in short summer conditions (I. Kazakov, 2009)

Remontant raspberries are a group of raspberry varieties characterized by the ability to bear fruit on both biennial and annual shoots. This property was acquired due to the accelerated morphogenesis of generative buds and their awakening in the upper part of annual shoots (Kazakov I.V., 2007).

The popularity of remontant raspberries is explained by the fact that due to its biology and special cultivation technology, it is devoid of many of the disadvantages that ordinary raspberries have when they are harvested at annuals. Raspberries with the traditional type of fruiting on the shoots of the second year in the conditions of southeast Kazakhstan are often subjected to winter drying, which occurs due to the instability of winter conditions with alternating cold snap below -20^{0}C and thaws in the middle and end of winter and early spring.

At the same time, growth activity is initiated in the shoots, cambium cells begin to divide, not getting enough moisture from the root system in the sleeping state and lose their frost resistance, and then dry out, using the entire amount of moisture accumulated in the shoot. In addition, two-year-old shoots of traditional varieties require additional care, which involves tying them to a trellis, the installation of which is not obligatory on maintenance varieties, and the cutting of shoots is not selective manual but continuous mechanized, which significantly reduces the cost of manual labor. To date, a number of varieties have already been bred in which the awakening of the kidneys occurs on most of the shoots in the first year of its development. Of great interest is the chemical stimulation of the awakening of the kidneys with the help of drugs of growth regulators of the retardant type that stop the growth of the shoot and cause its thickening.
Organic plant growth regulators are drugs that stimulate the production of special phytoharmones in plant tissues - low molecular weight organic substances that control all processes of plant development.
All growth regulators for a plant have significant activity, due to which the processes of survival and adaptation of young plants to new conditions are significantly accelerated. After treatment with these drugs, the plant becomes more resistant to fungal infection, and transfers the transplant more easily. Cultures that have been cultivated by growth regulators are less likely to be attacked by pests; later, they enter the phase of flowering and fruiting much earlier than “their brethren” (Shapoval O.A., 2009).
Retardants are synthetic substances of different nature that inhibit the growth of stems and shoots. They are one of the varieties of growth regulators. The main purpose of the use of retardants is to obtain plants with strong branching, a strong stem and a powerful root system (Quito V.E., 2018).

Methods and materials :

The experiments were carried out in the farm "Aidarbayev" in the village of "Saymasay", Enbekshikazakh district of Almaty region. The studies were conducted in seasons with positive weather conditions. In 2019, the second half of the growing season was characterized by significantly hot, dry-arid weather. The maximum daily air temperature in July rose to 35^0C. August-September was characterized by high air temperature, which was warmer than usual at 7^0C. Such weather conditions accelerated the ripening of berries of remontant raspberries. Therefore, a positive effect on the morphological structure of the leaf surface was also noted. The natural and climatic conditions of the Enbekshikazakh district of the Almaty region are generally favorable for the cultivation of berry crops, especially raspberries.
The zones and the adjacent foothill plains located at an altitude of 700 to 750 m above sea level cover Enbekshikazakh district. The soils of the experimental plot are meadow-chestnut with no signs of salinization (table 1). The average annual temperature is +6.2 ... + 8 degrees. The frost-free period is 160-180 days. There are moderately hot, long summers, a large number of sunny days, moderately warm winters (Balgabaev N.N., 2016) The sum of positive temperatures for the summer period is 3450-3750 ^{0}C, and the sum of temperatures for the period above 10^0C ranges from 3100-3400^{0}C. Relative humidity is not high and ranges from 46-48%, with an average perennial 55-60%. The amount of precipitation is significantly reduced by 2-3 times compared with spring, during the summer it is possible to have a monthly rainfall of 1 day. Autumn temperature transition through 15^0C begins in the 3rd decade of September – early October. The duration of this period ranges from 30–51 days. The amplitude of daily fluctuations in day and night temperatures reaches 25-30 ^{0}C. Annual rainfall ranges from 350-420 mm. During the warm season, 120-300 mm of precipitation falls.

Table 1 - Content of humus, gross nitrogen, phosphorus and CO_2 carbonates in meadow-chestnut soil

Depth, cm	Humus, %	Total nitrogen, %	C:N	Total phosphorus,%	CO_2, %
0-10	2,45	0,120	11,8	0,19	5,80
10-20	2,44	0,119	11,9	0,16	5,84
40-50	1,00	0,060	9,6	0,17	5,88
70-80	0,46	0,039	6,8	0,14	7,30
100-110	0,40	0,035	6,6	0,13	8,44
140-150	0,30	0,029	6,0	0,12	5,13

Planting scheme was 2.5x0.5 (8,000 plants). Observation and accounting: in the experiments, phenological and biometric observations were carried out. The yield and its quality were taken into account as well as certain physiological parameters of plants and the biochemical composition of berries were established. The experiment was repeated in two times with 10 testing plants in each of them (B.A. Dospekhov 1985).

- Phenological phases of the development of remontant raspberries: emergence of shoots, the appearance of inflorescences, the beginning of flowering, mass flowering, the beginning of ripening, mass ripening, the end of ripening;
- The number of shoots was counted individually per linear meter; the length of the shoots was measured with a ruler; the diameter of the shoots with a caliper, the area of the leaf surface for all variants of the experiment using a palette;
- The average weight of the fruit was determined for each harvest; for this 100 fruits were taken to determine the maximum weight of one fruit; 100 of the largest berries were weighed after each harvest;
- Biochemical evaluation of the fetus was carried out according to generally accepted methods: soluble solids - refractometric; solids - by drying; sugar by Bertrand; titratable acids - by electrometric titration; Vitamin C - according to Murri (Ermakov A.I., 1987).

The objects of research were promising varieties of remontant raspberries Bryanskoe divo of Russian selection and Polish variety - Polka.

Experiment included research of the influence of retardants on the stability of shoots of 2 varieties of remontant raspberries "Bryanskoe Divo" and "Polka".

An experiment was conducted at the experimental site to study retardants for the stability of shoots of raspberry varieties. The experience was laid from 2018 to 2019, in the raspberry field of at "Aidarbayev" farm. There were 2-fold repetition variants for plots, 10 accounting plants. The following drugs were used in the experimental plot: Sprayfert - Biostim, Reglon, Tse-Tse-Tse.

Description of the drugs:

Sprayfert 243 includes 22% nitrogen in nitrate (14), ammonia and mainly urea form, water-soluble phosphorus P_2O_5 (28%) and potassium K_2O (21%), Zn and Mn (0.1%), thus, is a unique fertilizer that is used by foliar application to protect against any kind of stress, solving the corresponding negative effects and accelerating flowering, leaf growth and yield (Sprayfert 312, 2018).

Biostim - has a gibberellin effect, provides quick intake and easy absorption of nutrients by the plant through the leaves. The increased content of free amino acids determines the protection of plants from weather, chemical and other stresses, resistance to diseases and adverse conditions. Advantages: 1) accelerates the plant's release from stress; 2) increases resistance to extreme weather conditions. Provides plants with a

balanced composition of amino acids of plant origin and trace elements. It activates the vitality of plants, has a powerful anti-stress effect (Kirillov N.A., 2015).

Reglon - is a powerful, fast-acting and widely used in agriculture. Within a few days after treatment with the drug, the reglone-green parts of cultivated plants and weeds dry out, which allows one to effectively adjust the timing of the harvest. It accelerates the drying process, especially with uneven ripening of plants as well as facilitates cleaning (Babayants M.V., 2018)

Tse-Tse-Tse - the most widely used in plant growing retardant is chloromechatokchloride (CCC) (chloride (2-chloro-ethyl) -trimethylammonium), based on which drugs such as Tse-Tse-Tse 750 are created. It inhibits stem growth by inhibiting the biosynthesis of gibberellins. The content of chlorophyll in the plants treated with chloromequate-chloride increased, which is associated both with an increase in its synthesis on the 5-6th day after treatment and with a delay in its destruction. Once in the plant, the drug turns into natural metabolites - choline and betaine. It increases the number of lateral productive shoots. (Yakushev V.P., 2010)

Research results :

Phenological observations have indicated that the use of drugs of the retardant type on raspberry varieties Bryanskoe divo and Polka affect their passage of individual phases of the growing season. Thus, firstly it was during naturally simultaneous beginning of the growing season in the 3rd decade of March, when shoots appeared very amicably as well as next phase, which took place after two treatments, already began at different times.

In comparison with control (water treatment), the earliest occurrence of inflorescences, flowering, as well as the remaining key phases of raspberry development took place after treatment of the shoots with the herbicide type retardant Reglon. Moreover, the first phase of generative development accelerated by 5 days, flowering by 6 days, and the beginning of ripening by 7 days. Treatments with the most common Tse-Tse-Tse retardant also accelerated the passage of the generative phases by plants, but to a slightly lesser extent, by 2 to 3 days later than Reglon. The use of the Sprayfert-Biostim combination to inhibit the vegetative growth accelerated the passage of individual phenological phases of development to a not so significant extent, by only 1 - 2 days.

The conditions of the year did not significantly affect the nature of the reactions of plants after treatments i.e. the influence of the used retardants was characterized by significant stability, varying insignificantly over the years, while maintaining the main differences between the variants. It should also be noted that this pattern was preserved in the varietal aspect, and the Bryanskoe divo variety should be attributed to an earlier group compared to the Polka variety. This affected, in particular, the ripening of the crop, which fully ripened in the Russian variety, and in the Polish one, the last-set berries were damaged by autumn frosts and, therefore, did not allow this variety to fully realize its productivity potential.

Table 2 - The Effect of retardants on the biometric indicators of varieties of remontant raspberries (2018 – 2019)

Variants	Number of shoots pcs/linear m	The height of the shoots when ripe, cm	Diameter of shoots, mm	Number of leaves pcs /linear m	Average area of 1 leaf blade, cm^2	Sheet surface area, m^2/linear m	Sheet surface area m^2/ha

Bryanskoe divo							
Control (water)	15,3 17,6	114,0 137,5	7,7 8,9	129,6 131,1	79,8 80,8	1,03 1,05	4120 4200
Sprayfert Biostim	17,0 19,0	135,2 137,3	8,5 9,5	134,7 136,6	87,8 99,6	1,18 1,36	4720 5440
Reglon	9,8 10,6	94,7 101,9	5,9 6,7	117,2 115,0	59,6 63,7	0,69 0,73	2760 2720
Tse-Tse-Tse	16,9 18,6	120,8 122,9	8,3 9,1	120,5 121,8	69,8 77,6	0,84 0,94	3360 3560
Polka							
Control (water)	16,8 18,0	99,3 98,4	6,0 8,6	133,9 135,8	89,2 90,5	1,19 1,22	4760 4880
Sprayfert Biostim	14,5 15,0	124,0 134,2	7,8 8,8	138,2 140,1	95,3 98,2	1,31 1,37	5240 5480
Reglon	17,9 19,3	69,2 79,3	6,7 5,9	128,7 133,9	62,0 71,0	0,79 0,95	3160 3800
Tse-Tse-Tse	10,7 12,0	116,0 117,3	9,3 9,9	132,2 134,1	78,5 87,5	1,03 1,17	4120 4680

Note: numerator - 2018, denominator – 2019

Retardant treatments influenced the vegetative development of raspberry varieties. Moreover, the first phase, the number of shoots formed in the experimental variants did not differ significantly due to treatments in a later period, when shoots appeared already above the soil surface. Despite the accelerated generative development after treatments with the Sprayfert-Biostim combination, the expected containment of the vegetative growth of shoots was not noted. In that variant, the shoots exceeded the control in height by 2 - 3%, and in diameter by 5 - 7% in 2018 and 2019, respectively.

In other variants, the retardant effect, especially after treatment with Reglon, was significant. After treatments with Reglon, shoots in average decreased over the years in height by 0.2 times, and in the diameter of the stem by 20 - 25%. There were no deviations in these indicators, both by years and by species. A similar pattern was observed when applying the retardant Tse-Tse-Tse only to a slightly lesser extent than that of Reglon.

Naturally, morpho-anatomical changes in the development of the assimilation surface retained the patterns noted during shoot development. Retardants Reglon and Tse-Tse-Tse restrained the development of the leaf apparatus. At the same time, the size of the leaf blade decreased in two years after treatment with Reglon by 35%, and Tse-Tse-Tse by 26%. According to the Sprayfert-Biostim combination, the previously noted tendency to increase the vegetative organs of plants remained. The average leaf blade area increased by 30% compared to the control (table 2).

Quantitative data showed leaves per unit area of the land, depended mainly on the height of the shoots, which were the largest when processed with the Sprayfert-Biostim combination, and the smallest in the Reglon variant. The index total leaf area per unit area of land determines the productivity potential of any crop. It is derived from the number of leaves and the average area of the leaf blade. Naturally, in the variant with the combination of two drugs, this indicator was the largest 1.3 times exceeding the control, on average, over 2 years. The smallest area of the leaf apparatus by 65% was noted in the Reglon variant. It should also be noted that the Polka variety was more vigorous in comparison with the Bryanskoe divo variety. The main indicator of this symptom in remontant raspberries was the height of the shoots, which was in average by 10% higher for variants and years. Chlorophyll determination This is a quantification of pigments without prior separation. Quantitative analysis without separation and without the use of standards consists of preparing a pigment extract. For this a 50-100 mg sample has to be taken and extracted with 96% ethyl alcohol in 25 cm^3 cones. Furthermore, determination of the optical density of the resulting solution on a spectrophotometer at wavelengths, 665 nm - chlorophyll *a*, 649 nm - chlorophyll *b*, 452.5 nm carotenoids and subsequent mathematical calculation should be done.

The optical density of the pigment extract is determined by 665, 649 and 452.5 nm (for ethanol) using cuvettes with an absorbing layer thickness of 10 m.

The concentration of chlorophylls *a* and *b*, carotenoids was calculated by the formulas in mg / g taking into account the weight and dilution.

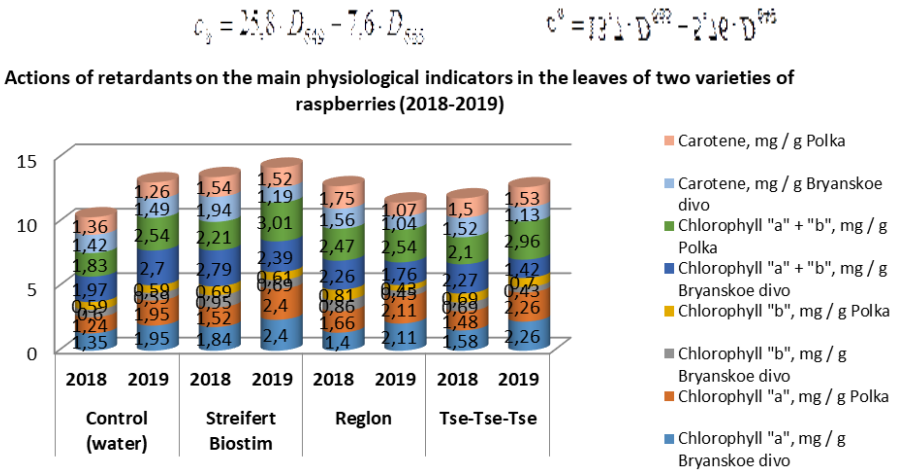

Figure 1 - The actions of retardants on the main physiological indicators

in the leaves of two varieties of raspberries (2018 - 2019) From physiological indicators, the effect of retardants should affect the content of chlorophyll on the direct line associated with the process of photosynthesis. Natural was a general increase in chlorophyll, *a* and *b*, and naturally, their sum. To the greatest extent, those occurred in the Sprayfert-Biostim variant by 21%, and in the other two variants only by 98-72%, respectively (Figure 1).

Table 3 - Effects of retardants on biochemical quality indicators of remontant raspberries (2018 - 2019)

Variant	Vitamin "C", mg/%	Total sugar, %	Mono	Acidity, %	Soluble solids, %

	State Standard 24556-89		State Standard 8756.13-87		saccharides, % State Standard 8756.13-87		State Standard 25555.0-82		State Standard 28561-90	
	Bryanskoe divo	Polka	Bryanskoe divo	Polka	Bryanskoe divo	Polka	Bryanskoe divo	Polka	Bryanskoe divo	Polka
Control (water)	19,2 20,1	23,2 22,2	11,7 10,8	10,6 10,7	8,6 8,6	8,6 8,6	1,0 1,0	1,0 1,0	9,1 9,4	7,6 8,4
Sprayfert Biostim	24,5 23,6	24,3 24,2	10,3 11,5	11,6 11,5	8,4 8,5	8,7 8,7	1,0 1,0	1,0 1,0	9,6 11,0	11,3 11,2
Reglon	24,0 24,0	22,3 22,1	12,0 12,0	12,4 12,3	8,7 8,7	8,7 8,7	0,9 0,9	1,0 1,0	7,8 8,4	8,5 9,8
Tse-tse-tse	22,7 23,7	23,5 24,5	12,3 11,8	11,6 11,5	8,7 8,6	8,7 8,7	1,0 1,0	1,1 1,1	8,6 9,2	9,3 9,5

Note: numerator - 2018, denominator – 2019

A significant effect of retardants on the biochemical composition of the experiment was not noted. Indicators varied, both by year and by varieties. It follows that retardant treatment does not impair the value of raspberries (table 3). Retardants Reglon and Tse-Tse-Tse having a depressing effect on the vegetative development of plants also contributed to a decrease in productivity. Moreover, this oppression affected both the quantitative indicators and the morpho-anatomical structures of the fetus. The number of fruits decreased by 0.2 - 0.3 times, and their average weight by 20 - 25%, respectively. When treated with a combined drugs growth for both indicators was also observed in comparison with control. Thus, it was by 14% in terms of the number of berries and by 12% in their average weight productivity. In general, productivity

growth in this variant was in average 12% and real figures reached 11 t/ha (Figure 2). The greatest decrease in productivity in the experiment with Reglon variant was 66%. It was also established that the Bryanskoe divo variety was more productive (by 8%) and large-fruited (the average weight of berries was 14% more) compared to the Polk variety (table 4).

Table 4 - Productivity of introduced varieties of remontant raspberries (2018 - 2019)

Variants	**Berries numbers, pcs/linear m**		**The average weight of berries (g)**		**Productivity t/ha**	
	2018	2019	2018	2019	2018	2019
Bryanskoe divo						
Control (water)	460,0	473,0	4,3	5,2	7,9	9,8
Sprayfert-Biostim	480,0	495,0	4,7	5,6	9,0	11,0
Reglon	415,0	420,0	3,5	3,9	5,8	6,5
Tse-Tse-Tse	432,0	465,0	4,2	4,8	7,2	8,9
Polka						
Control (water)	589,0	520,0	3,0	4,3	7,0	8,9
Sprayfert-Biostim	592,0	557,0	3,4	4,4	8,0	10,7
Reglon	380,0	400,0	3,8	4,0	5,7	6,4
Tse-Tse-Tse	370,0	475,0	3,9	4,2	6,8	7,9
SSD $_{0,5}$	1,1					
Sx, %	7,6					

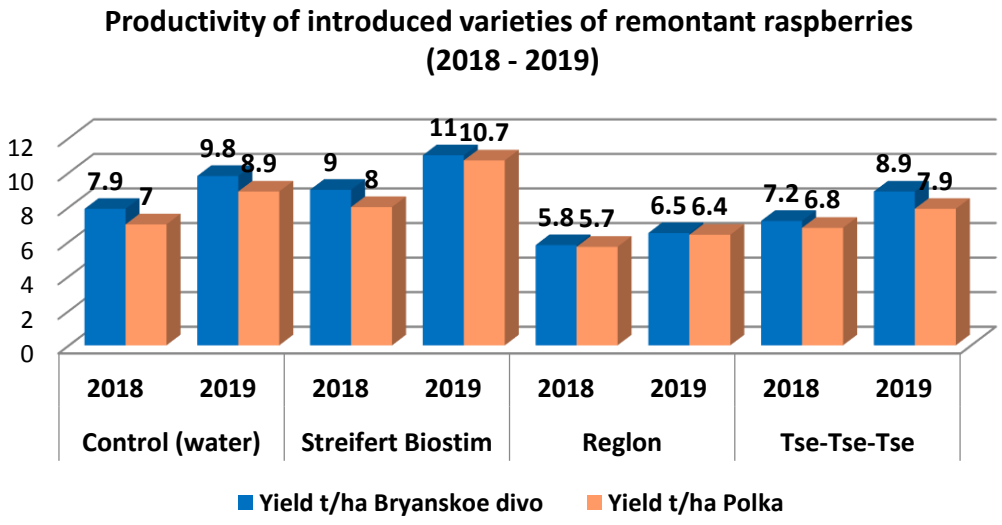

Figure 2 - Productivity of remontant raspberries t/ha varieties (2018 - 2019)

The discussion of the results :

In the conducted experiment, a number of patterns were established and the influence of retardants on the growth, development and productivity of remontant raspberries was established. The containment of growth processes, not accompanied by the expected thickening of shoots, occurred during the treatment of plants with of Tse-Tse-Tse and Reglon. Reglon, despite a single decrease in its herbicidal dose had a depressing effect on all growth processes, causing an accelerated passage of all vegetation phases, especially the ripening phase of the crop by 7 days. This was mainly due to the fading of the berries.

Their number also decreased. The explanation for the increase in the content of chlorophyll in the leaves can probably be the deviation of the entire plant and directly of the leaf apparatus, which significantly decreased to the xeromorphic structure of all plant organs in that variant. Treatment with a combined preparation consisting of Biostim and Sprayfert did not produce a clear retardant effect, however, thickening of shoots and acceleration of the passage of development phases were caused.

At the same time, all metameric organs, including fruits, as well as the content of chlorophyll, increased. As a result, productivity has grown significantly. This suggests the complex positive effect of this combination of drugs on remontant raspberries. In general, for all the studied drugs of the retardant type, the absence of their negative effect on the biochemical composition of berries was established. It should also be noted the advantage of the Russian variety Bryanskoe Divo over the Polish variety Polka over the whole range of economically useful traits.

Conclusion :

The phenological phase of the development of repair raspberries took place after treatment of the shoots with the herbicide type retardant Reglon. Moreover, the first phase of generative development accelerated by 5 days, flowering by 6 days, and the beginning of ripening by 7 days.

- The retardant treatment of Tse-Tse-Tse also accelerated the passage of the generative phases by the plants, however, to a somewhat lesser extent, by 2 to 3 days later than that of Reglon.
- The use of the Sprayfert-Biostim combination to inhibit the vegetative growth accelerated the passage of individual phenological phases of development to a not so significant extent, by only 1 - 2 days.

Generative development after treatments with the Sprayfert-Biostim combination of the expected containment of vegetative shoot growth was not noted. In this variant, the shoots exceeded the control in height by 2 - 3%, and in diameter by 5 - 7% in 2018 and 2019, respectively.

Reglon and Tse-Tse-Tse restrained the development of the leaf apparatus. At the same time, the size of the leaf blade decreased on average two years after treatment with Reglon by 35%, and Tse-Tse-Tse by 26%. According to the Sprayfert-Biostim combination, the previously noted tendency to increase the vegetative organs of plants remained, the average leaf blade area increased in this variant by 30% compared to the control.

The productivity index was shown to be high at the Bryansk divo variety, the Sprayfert-Biostim variant. In average it was 12% and real figures reached 11 t/ha.

References :

1. Kazakov I.V., Kulagina V.L., Evdokimenko S.N. Results and prospects of raspberry breeding in the central region of Russia. Journal: “Fruit Growing and Berry Growing in Russia”, Volume 22, No. 2. M: 2009. - pp. 55-63

2. Kazakov, I.V., Sidelnikov, A.I., Stepanov, V.V. Remontant raspberries in Russia. Chelyabinsk: ed. Garden and Kitchen Garden, 2007. - P.144
3. Shapoval O.A., Vakulenko V.V., Prusakova L.D. Plant growth regulator for vegetables. Overview. Journal: Gavrish No. 3. 2009.- P. 14 – 19
4. Quito V.E., Abdelaal H.K. Features of the application of the Reggae retardant on spring triticale in the conditions of the Central region of the Non-chernozem zone. 2018 // Material of the international scientific-practical conference Institute of Agroecology "Problems of the agricultural sector of the southern Urals and ways to solve them" Chelyabinsk. -, 2018.- p. 95
5. Balgabaev N.N., Kalashnikov P.A., Ospanbev Zh.O., Bayzakova A.E. Possible application area of self-pressure drip irrigation systems in the Shelek river basin of Enbekshikazakhsky district of Almaty region. Journal: Science and the World. Volume 1 No. 11 (39). 2016. - S. 64-68
6. Dospekhov B.A. Methodology of field experience. M., 1985. - p. 351
7. Ermakov A.I., Arasimovich A.A. et al. Methods of biochemical study of plants / ed. A.I. Ermakova. - 3rd ed. - L .: Agropromizdat., 1987 .-430 p.
8. Prifert 312 “SWISSGROW” catalog magazine, Turkey Antalya, 2018, p. 24-25
9. Kirillov N.A., Volkov A.I., Kulikov L.A. The experience of using the biostimulator "Biostim corn" and microfertilizers "Intermag pro corn". Journal: “Sugar beet” No. 9. M: 2015. - P. 36-37
10. Babayants M.V. The effect of the biological product Reglon on the increase in the weight of caraway seeds. 2018 // Materials of the XVII International Scientific and Practical Conference of graduate students and young scientists “Young Knowledge: Science, Practice and Innovation” Kirov, 2018 - P. 189
11. Yakushev V.P., Kanash E.V., Osipov Yu.A., Yakushev V.V., Lekomtsev P.V., Voropaev V.V. Optical criteria for contact and remote diagnostics of the state of wheat crops and the effectiveness of photosynthesis against a background of mineral nutrition deficiency. Scientific and theoretical journal: Agricultural Biology No. 3. 2010. - P. 94-101.