

The influence of preparations based on biologically active substances on the yield and quality indicators of potatoes in the conditions of the mountainous zone of the Kabardino-Balkarian Republic

*Irina Khanieva**, Kamaludin Magomedov, Aliy Boziev, Galimat Abidova, and Azamat Abidov

Kabardino-Balkarian State Agricultural University named after V.M. Kokov, 360004, KBR, Nalchik, Lenin Avenue, 1v, Russia

Abstract. In the conditions of the Kabardino-Balkarian Republic, in the mountainous zone, field studies were carried out to identify the effectiveness of the use of drugs based on biologically active substances on the yield and quality indicators of potatoes in the mountainous zone of the Kabardino-Balkarian Republic. The following potato varieties Goryanka and Nart 1 were studied as objects of research. The following preparations were the subject of research: Lignohumate AM, Polydon iodine, Fulvigrain Stimulus Pro, Zircon and BisolbiSan, Zh, Succinic acid. Analysis of the data obtained in the course of the research shows that in the variants of the combined use of Lignohumate AM and preparations based on biologically active substances, a stable and high increase in potato yield was noted in all years of the study. The highest yield for the Goryanka variety was noted in the variants of joint application with the Zircon preparation - 8.1 t/ha or 34.5%, for the Nart 1 variety in the variant of the combined application of BisolbiSan - 10.7 t/ha or 36.0%. The use of the drug Lignohumate AM led to an increase in the yield of tubers for varieties Goryanka and Nart 1 by 22.6% and 26.3%, respectively.

1 Introduction

Potato is one of the most demanded agricultural crops in Russia. In the world consumer market, only corn, wheat and rice are ahead of it.

In Russia, the potato in terms of national economic and strategic importance is second only to grain, the traditional measure of agricultural development. It is included in the daily diet of most Russians.

The gross potato harvest in the world is growing and, according to FAOSTAT, averaged 374 million tons, with an average yield of 17.2 t/ha. In terms of gross potato production, Russia ranks third among the largest producers in the world, after China and India. In

* Corresponding author: imhanieva@mail.ru

Russia, the gross harvest of potatoes in 2019 amounted to more than 21.1 million tons (according to Rosstat), in the large-scale sector, production increases annually and amounts to about 7 million tons with a yield of 21.0-23.0 t/ha [3].

In this regard, research aimed at the development of new and improvement of existing cultivation technologies, the use of Lignohumate AM and preparations (Polydon iodine, Fulvigrain Stimul Pro, Zircon and BisolbiSan, Zh, Succinic acid), allowing to reveal and maximize the genetic potential of varieties, for obtaining stable yields with high technological properties are relevant and of great economic importance.

The purpose of the work is to study the effect of Lignohumate AM and preparations based on biologically active substances (Polydon iodine, Fulvigrain Stimulus Pro, Zircon and BisolbiSan, Zh, Succinic acid) on productivity and quality indicators when grown on leached chernozems, in the conditions of the mountainous zone of Kabardino-Balkarskaya Republic.

To achieve this goal, the following **tasks** were assigned:

- study of preparations for preplant treatment of tubers: Polydon iodine, Fulvigrain Stimulus Pro, Zircon, BisolbiSan, Zh, Succinic acid;
- revealing the effect of the use of the drug "Lignohumate AM" and preplant treatment of tubers and plants with drugs based on biologically active substances on the yield and quality indicators of tubers of zoned potato varieties;

Scientific novelty. For the first time in the conditions of a mountainous zone on leached chernozems, when growing potato varieties Goryanka and Nart, the effectiveness of the joint use of the drug "Lignohumate AM" and drugs: Polydon iodine, Fulvigrain Stimulus Pro, Zircon and BisolbiSan, Zh, Succinic acid was established. A list of preparations based on biologically active substances for pre-planting treatment of potato tubers has been identified, allowing to maximize the potential of potato varieties.

2 Materials and research methods

The experimental part of the experiments to study the effect of the use of the Lignohumate AM preparation and preplant treatment of tubers and plants with preparations based on biologically active substances on the productivity and quality indicators of potatoes was carried out on the basis of Belokamenskoye SHP LLC for three years (2019 - 2021). The objects of research were zoned potato varieties Goryanka and Nart. The research included laboratory and field experiments.

The consumption of the working solution of biologically active substances was 10 liters per 1 ton of potato tubers. The experiment was repeated four times. On the 10th day of germination, the number of awakened buds was calculated, on the 30th day - the mass of sprouts and roots of seedlings of potato tubers.

The placement of plots in the experiment was randomized, 4-fold repetition. The area of the plot was 50 sq.m.

Yield accounting data and other biometric indicators were subjected to mathematical processing by the method of analysis of variance for a two-factor experiment using a computer program for calculating NSR 05. [7].

Factor A is the treatment of tubers and plants, factor B is the varieties studied in the experiment [2].

The experience consisted of the separate and joint use of Lignohumate AM and preparations based on biologically active substances) the use of Lignohumate AM and preparations based on biologically active substances:

1. Control (water);
2. Polydon iodine (tubers 300 ml/t + plants 150 ml/l);
3. Fulvigrain Stimulus Pro (tubers 3 l/t + plants 6 l/l);

4. Zircon (tubers 5 ml/t + plants 10 ml/l);
5. BisolbiSan (tubers 2 ml/t + plants 10 ml/l);
6. Lignohumate AM - 5 g/10 l;
7. Lignohumate AM 5 g/10 l + Polydon iodine (tubers 300 ml/l + plants 150 ml/l);
8. Lignohumate AM 5 g/10 l + Fulvigrain Stimulus Pro (tubers 3 l/t + plants 6 l/l);
9. Lignohumate AM 5 g/10 l + Zircon (tubers 5 ml/t + plants 10 ml/l);
10. Lignohumate AM 5 g/10 l + BisolbiSan (tubers 2 ml/t + plants 10 ml/l).

The treatment of potato tubers was carried out with preparations based on biologically active substances, which make it possible to maximize the potential of varieties at the initial stages of potato plant growth. The crops were processed in the phase of full shoots, according to the regulations approved by the manufacturer. [2].

The consumption rate of the working solution was: tubers - 10 l/t, crops - 300 l/ha.

Predecessor - busy steam. Under the main tillage, manure was introduced - 50 t/ha. Potato cultivation technology is generally accepted for this growing area. [four].

During the study, the following records and observations were made:

- the number and mass of tubers in the bush ,
- area of leaves by cutting ,
- photosynthetic potential (PP) and net productivity of photosynthesis (NPP) [2].
- accounting of the harvest was carried out by the method of continuous harvesting and structural analysis of the products obtained (method of the State Variety Testing, 1975). [3].

Accounting for the economic efficiency of the use of preparations based on biologically active substances and the preparation Lignohumate AM in the cultivation of potatoes was carried out at tariff rates and prices for potatoes in 2019-2021. [7].

3 Research results

The yield of agricultural crops is an integral indicator that reflects the response of the plant organism to growing conditions, including the nutritional regime and the intensity of metabolic processes that change during plant growth [8]. The use of the drug Lignohumate AM and the treatment of tubers and plants with preparations based on biologically active substances stimulates the friendly and rapid emergence of seedlings, stimulates the growth and development of plants, increases the indices of PP and NPF, against the background of an improvement in the nutritional regime of plants, helps to increase the yield of potato tubers (Table 1).

In the course of the study, it was found that the highest yield increase among the preparations studied in the experiment is provided by the BisolbiSan preparation in 2020, the year was characterized as sufficiently moisture-provided, for the Goryanka variety, the use of the BisolbiSan preparation provided an increase in yield up to 17.8%.

2019 and 2021, according to weather and climatic conditions, were less favorable for the formation of the potato crop, the yield increase on the variants of using this drug was 13.6% and 12.5%.

In the experimental variants where Lignohumate AM was used, the greatest increase in yield for the Goryanka variety was noted in 2020 and 2021, the increase relative to the control variant was 22.8% and 19.9%, in 2019 the value of this indicator was 21.3%. The use of Fulvigrain Stimul Pro in 2019 made it possible to obtain a yield increase of 9.5%, in 2020 and 2021 the yield increase was 7.3% (Table 1).

Table 1. Effect of Lignohumate AM and preparations based on biologically active substances on the yield of potato varieties Goryanka and Nart 1

Variety	Option	Productivity, t/ha				% to control
		2019	2020	2021	Medium	
Goryanka	Control variant (water)	22.1	28.6	23.2	24.6	100.0
	Polydon iodine (tubers 300 ml/t + plants 150 ml/l)	22.4	28.3	22.9	24.5	99.6
	Fulvigrain Stimulus Pro (tubers 3 l/t + plants 6 l/l)	24.2	30.7	24.9	26.6	108.1
	Zircon (tubers 5 ml/t + plants 10 ml/l)	24.0	32.9	26.8	27.9	113.4
	BisolbiSan (tubers 2 ml/t + plants 10 ml/l)	25.1	33.7	26.1	28.3	115.0
	Lignohumate AM - 5 g/10 l	26.8	34.3	28.5	29.9	121.5
	Lignohumate AM 5 g/10 l + Polydon iodine (tubers 300 ml/l + plants 150 ml/l)	27.2	34.8	28.3	30.1	122.3
	Lignohumate AM 5 g/10 l + Fulvigrain Stimul Pro (tubers 3 l/t + plants 6 l/l)	28.1	35.4	29.1	30.9	125.6
	Lignohumate AM 5 g/10 l + Zircon (tubers 5 ml/t + plants 10 ml/l)	28.6	37.8	31.6	32.7	132.9
	Lignohumate AM 5 g/10 l + BisolbiSan (tubers 2 ml/t + plants 10 ml/l)	28.9	36.7	30.9	32.2	130.9
Nart 1	Control variant (water)	25.0	39.2	28.3	30.8	100.0
	Polydon iodine (tubers 300 ml/t + plants 150 ml/l)	25.5	39.6	28.9	31.3	127.2
	Фульвигрейн Стимул Про (клубни 3 л/т + растения 6 л/л)	25.3	42.1	30.1	32.5	132.1
	Zircon (tubers 5 ml/t + plants 10 ml/l)	26.8	43.1	31.2	33.7	137.0
	BisolbiSan (tubers 2 ml/t + plants 10 ml/l)	26.8	43.3	33.1	34.4	139.8
	Lignohumate AM - 5 g/10 l	31.7	48.5	35.5	38.6	156.9
	Lignohumate AM 5 g/10 l + Polydon iodine (tubers 300 ml/l + plants 150 ml/l)	31.8	48.1	35.6	38.5	156.5
	Lignohumate AM 5 g/10 l + Fulvigrain Stimul Pro (tubers 3 l/t + plants 6 l/l)	32.8	49.5	35.7	39.3	159.7

Lignohumate AM 5 g/10 l + Zircon (tubers 5 ml/t + plants 10 ml/l)	31.7	49.8	37.4	39.6	161.0
Lignohumate AM 5 g/10 l + BisolbiSan (tubers 2 ml/t + plants 10 ml/l)	33.4	50.1	40.2	41.2	167.5
HCP05	1.33	1.39	1.10	-	-
HCP05 Factor A (processing option)	0.98	0.94	0.84	-	-
HCP05 Factor B (grade)	0.41	0.52	0.44	-	-

The analysis of the above data shows that variety Nart 1 is more responsive to the use of the drug Lignohumate AM than variety Goryanka, the drug itself allows you to remove the negative impact of adverse weather and climatic conditions during the formation of the crop.

On the options for the joint use of the Lignohumate AM preparation and preparations based on biologically active substances in the Goryanka variety, the maximum increase in yield in 2020 and 2021 was provided by the Zircon preparation, respectively, 33.5% and 38.0%, in 2019 the BisolbiSan preparation - 32.3%. The combined use of Fulvigrain Stimulus Pro led to a further increase in productivity relative to the option where Lignohumate AM was used.

The combined use of BisolbiSan and Lignohumate AM allowed variety Nart 1 to more fully realize its genetic potential in adverse weather and climate conditions in 2019 and 2021, the yield increase in these years was the largest and amounted to 33.6% and 42.0% respectively.

Analysis of the data shows that the preparations studied in the experiment based on biologically active substances contribute to an increase in the yield of potatoes of the Nart 1 variety by 27.2 - 39.8%, when combined with Lignohumate AM, the value of this indicator increases to 67.5%, relative to the control variant. For the Goryanka variety, preparations based on biologically active substances contribute to an increase in yield by 9.6 - 15.0%; in the variants of combined use with Lignohumate AM, the value of this indicator increases to 32.9% relative to the control variant. [5]. The steadily increasing anthropogenic load on the soil, the reduction in application rates or the complete rejection of organic fertilizers, together with the pesticide load, have led to the fact that in recent years the starch content of potatoes has decreased, its taste has deteriorated, the content of nitrates and heavy metals in products has increased, and there is an increase in decay potatoes during storage [9].

The nature of the accumulation of dry matter and starch in potato tubers depends on the genetic characteristics of the variety, organomineral nutrition of plants and soil and climatic conditions [2].

An analysis of the data obtained during laboratory tests showed that the use of Lignohumate AM and preplant treatment of tubers and vegetative plants with preparations based on biologically active substances affect the content of solids and starch (Table 2).

The use of the drug Fulvigrain Stimulus Pro and the drug Lignohumate AM made it possible to form the highest content of dry matter and starch in the Goryanka variety, relative to the control variant, the value of this indicator increased by 1.9% and 1.3%. In the variants where the Zircon preparation was used together with the Lignohumate AM preparation, the value of these indicators increased by 1.5% and 1.0%, and in the variant with the BisolbiSan preparation - by 1.3% and 0.9% relative to the control variant. In the variants of the experiment, where the drug Lignohumate AM was used, the increase in the dry matter content was 1.0% and starch by 0.7%. [6].

Table 2. The effect of Lignohumate AM and preparations based on biologically active substances on the quality indicators of potato tubers (average for 2019 - 2021)

Experience options	Goryanka				Nart1			
	Dry matter		Starch		Dry matter		Starch	
	%	± relate to control	%	± relate to control	%	± relate to control	%	± relate to control
Control variant (water)	16.3	-	12.1	-	22.1	-	15.6	-
Polydon iodine (tubers 300 ml/t + plants 150 ml/l)	16.3	-	12.3	+ 0.2	22.8	+ 0.7	15.7	+ 0.1
Fulvigrain Stimulus Pro (tubers 3 l/t + plants 6 l/l)	16.7	+ 0.4	13.5	+ 1.4	23.4	+ 1.3	15.8	+ 0.2
Zircon (tubers 5 ml/t + plants 10 ml/l)	16.7	+ 0.4	13.4	+ 1.3	23.0	+ 0.9	16.6	+ 1.0
BisolbiSan (tubers 2 ml/t + plants 10 ml/l)	17.0	+ 0.7	13.6	+ 1.5	23.2	+ 1.1	15.7	+ 0.1
Lignohumate AM - 5 g/10 l	17.2	+ 0.9	13.8	+ 1.7	24.1	+ 2.0	16.4	+ 0.8
Lignohumate AM 5 g/10 l + Polydon iodine (tubers 300 ml/l + plants 150 ml/)	17.0	+ 0.7	13.6	+ 1.5	24.0	+ 1.9	16.3	+ 0.7
Lignohumate AM 5 g/10 l + Fulvigrain Stimul Pro (tubers 3 l/t + plants 6 l/l)	18.1	+ 1.8	14.4	+ 2.3	24.5	+ 2.4	16.7	+ 1.1
Lignohumate AM 5 g/10 l + Zircon (tubers 5 ml/t + plants 10 ml/l)	17.7	+ 1.4	14.1	+ 2.0	24.1	+ 2.0	16.2	+ 0.6
Lignohumate AM 5 g/10 l +	17.5	+ 1.2	15.0	+ 2.9	23.8	+ 1.7	16.3	+ 0.7

BisolbiSan (tubers 2 ml/t + plants 10 ml/l)								
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According to the varieties studied in the experiment, it can be concluded that they responded differently to the drugs used in the experiment. As for the variety Goryanka, there is a tendency to increase the content of starch by 0.4 - 1.8% and dry matter by 0.2 - 2.9%. On the variants of the experiment, where the variety Nart 1 was studied, no significant changes in the values of the indicators of the content of starch and solids were found.

In the experimental variants where the preparation Lignohumate AM was used, an increase in the starch content by 1.7% for the early-ripening variety Goryanka and 0.8% for the mid-season variety Nart 1 was noted. Lignohumate AM and BisolbiSan - 15%.

For the variety Nart 1, the maximum value of the starch and dry matter content was noted in the variant of the combined use of preparations Lignohumate AM and Fulvigrain Stimul Proi - 16.3%.

Weather and climatic conditions during the years of research have a significant impact on the quality indicators of potato tubers. Thus, the maximum content of dry matter and starch for the potato varieties studied in the experiment was noted in the years when the moisture supply was below the average in 2019 and 2021, in these weather and climatic conditions, the Goryanka variety had the greatest difference relative to the control variant and the experimental variants where Fulvigrain preparations were used. Stimulus Pro and Zircon. This, in our opinion, is explained by the fact that these preparations Fulvigrain Stimulus Pro and Zircon have the ability to increase and reveal adaptive functions, contribute to the formation of protective systems that increase resistance during ontogenesis in unfavorable conditions, ensure plant resistance to adverse environmental factors, and also contribute to the normalization of all physiological processes occurring in plants during the entire growing season.

4 Conclusion

1. Analysis of the data obtained in the course of the research shows that in the variants of the combined use of Lignohumate AM and preparations based on biologically active substances, a stable and high increase in potato yield was noted in all years of the study. The highest yield for the Goryanka variety was noted in the variants of joint application with the Zircon preparation - 8.1 t/ha or 34.5%, for the Nart 1 variety in the variant of the combined application of BisolbiSan - 10.7 t/ha or 36.0%. The use of the drug Lignohumate AM led to an increase in the yield of tubers for varieties Goryanka and Nart 1 by 22.6% and 26.3%, respectively. The use of preparations based on biologically active substances has a significant impact on the yield, so for the Goryanka varieties, the value of this indicator increased by 8.5 - 15.7%, for the Nart 1 variety - by 7.1 - 12.1%.

2. In the variants of the combined use of drugs, there was an increase in the content of starch and dry matter in potato tubers, respectively: in the Goryanka variety by 0.5 - 1.3% and 0.8 - 1.9%, in Nart 1 - by 0.7 - 1.1% and 0.8 - 1.5%. The introduction of the drug Lignohumate AM contributed to an increase in these indicators in the studied varieties from 0.7 to 1.1%.

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