BIO Web of Conferences **238**, 01005 (2026) https://doi.org/10.1051/bioconf/202623801005
ESDCA 2026

Effect of Biological Preparations on the Growth, Development, and Productivity of the Ranemo Potato Variety

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Abstract. This study investigates the effects of biological preparations on the growth, development, and yield productivity of the potato variety Ranemo. The research demonstrates that the application of biological products - Biodux, Zerebra Agro, and Biogrand - during pre-planting treatment and throughout the growing season, particularly at the early budding and flowering stages, contributes to obtaining high and high-quality marketable yields. The highest efficiency was observed with the use of the biological product Biogrand. When potato tubers were treated before planting at a rate of 200 ml/t, the yield reached 32.3 t/ha. Furthermore, foliar application during the growing season at a rate of 1000–1200 ml/ha resulted in yields of 37.6–37.8 t/ha. These results exceeded the control treatment (without biological preparations) by 10.5–10.7 t/ha, and surpassed the yields obtained with other biological products by 1.4–2.3 t/ha. The application of the biologically active preparation Biogrand under early planting conditions - combined with pre-planting treatment at 200 ml/t and foliar application during the growing season at the budding and early flowering stages at 1000–1200 ml/ha - ensures optimal plant growth and development, as well as significantly enhances productivity and overall yield.

1 Introduction

Globally, potato production is considered one of the leading sectors in ensuring food security and supplying the population with food products. In order to obtain high and high-quality yields, it is essential to use clean, high-reproduction certified seed material that is resistant to adverse soil and climatic conditions, as well as to apply effective biological preparations such as Biodux, Zerebra Agro, and Biogrand within integrated agronomic practices.

The development and widespread implementation of technologies for producing healthy, environmentally friendly, high-reproduction potato yields - based on minituber propagation and subsequent commercial production from minitubers - remain highly relevant today. In this context, pre-planting tuber treatment and foliar feeding during the

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budding and flowering stages using biologically active substances such as Biodux, Zerebra Agro, and Biogrand require further scientific justification and technological optimization.

The production of virus-free seed potatoes under in vitro conditions and the cultivation of high-quality commercial and seed yields from obtained minitubers are of particular importance for early, late, and double-cropping systems in the conditions of the Samarkand region. However, the technology for using Biodux, Zerebra Agro, and Biogrand during pre-planting treatment and foliar feeding at critical phenological stages (budding and flowering) has not yet been fully developed. Therefore, there is a need to design agro-technological approaches aimed at producing environmentally safe, high-quality yields.

Numerous studies on potato cultivation technologies - including planting time, planting methods, irrigation regimes, and agronomic practices - have been conducted by researchers such as D.T. Abdukarimov, V.I. Zuev, T.E. Ostonakulov, I.T. Ergashev, A.A. Elmurodov, H. Khonkulov, and Y. Abdullayeva, as well as international scientists including S.G. Wiersema, P.C. Struik (Germany), T.W. Tibbits, W. Cools, R.M. Wheeles (USA), W.C. Yu (South Korea), W.J. Lommen (Netherlands), V.D. Volkov (Kazakhstan), I.F. Golovatskaya, V.I. Anasimov, V.Yu. Dorofeev (Russia), and A. Huraychik (Belarus). Their findings have been widely published in scientific literature.

However, in recent years, local biotechnology laboratories have focused on the production of mini- and microtubers of potato varieties. In this context, the regulation of plant growth and development through the application of biologically active substances during the growing season, as well as the study of yield formation patterns and productivity indicators, has gained significant practical importance. Nevertheless, in the conditions of the Samarkand region, there is still a lack of a well-developed technology for using Biodux, Zerebra Agro, and Biogrand in early and double-cropping systems, particularly for optimizing plant growth, increasing yield potential, and improving marketable quality.

1.1 Aim of the Study

The aim of this study is to develop a cultivation technology for potato varieties grown from in vitro-derived minitubers under early planting conditions in the Samarkand region. The technology is based on the application of biologically active substances during pre-planting and growing stages to ensure optimal plant growth, development, and the production of high-quality yields.

1.2 Research Objectives

To study the effects of different biological preparations, application rates, and treatment periods on the growth and development of potato plants grown from in vitro-derived minitubers under early planting conditions.

To evaluate the influence of different biological preparations, application rates, and treatment periods on the productivity of the potato variety Ranemo.

To determine the effects of biological preparations on tuber formation, yield structure, total yield, and marketable yield under early planting conditions using minitubers.

To calculate the economic efficiency of potato production using optimized agronomic practices and develop practical recommendations for agricultural implementation.

2 Materials and methods

2.1 Experimental Objects

The objects of the study included irrigated meadow soils of the Samarkand region, the mid-early maturing potato variety Ranemo, 15–20 g minitubers produced under in vitro conditions in local biotechnology laboratories, and the biological preparations Biodux, Zerebra Agro, and Biogrand.

2.2 Research Methods

Field and production experiments were conducted using standard agronomic practices, including planting, crop management, harvesting, data recording, and statistical analysis. The research methodology was based on the generally accepted protocols of the Ministry of Agriculture and Water Resources (1983; 1989; 1990), the All-Russian Institute of Plant Science (1984; 1986), and the All-Russian Potato Research Institute (1967; 1989).

Phenological observations were carried out in accordance with the methodology of the State Variety Testing Commission (1974). Biometric measurements - including plant height, stem number, number of lateral branches, leaf number, and leaf area - were performed according to the standards of the All-Russian Potato Research Institute (1967; 1989).

The level of plant infection with viral diseases (S, X, Y, and M viruses) was determined using serological methods as well as visual assessment techniques.

Productivity parameters were evaluated by selecting 20 plants from each experimental plot, following the methodology of the All-Russian Potato Research Institute (1967; 1980). Yield, marketable yield, seed tuber yield, and reproduction coefficient were determined according to established standards.

Seed quality indicators - such as virus infection level, the proportion of degenerated tubers, and subsequent reproduction yield - were assessed using the methodology of T.E. Ostonakulov.

2.3 Study Area

The experimental work was conducted at the Samarkand Experimental Station of the Scientific Research Institute of Vegetable, Melon and Potato Crops. The region is characterized by a sharply continental climate and is located at an altitude of 720 meters above sea level.

The average annual air temperature ranges from 14.4°C to 16.0°C, with absolute maximum temperatures reaching +44–47°C and minimum temperatures dropping to −14–16°C. The average wind speed at the experimental station is 8–10 m/s.

2.4 Experimental Design and Conditions (2023–2025)

The experiments were conducted during 2023–2025 using the potato variety Ranemo grown from in vitro-derived minitubers under early planting conditions. The study focused on the effects of pre-planting and in-season applications of the biological preparations Biodux, Zerebra Agro, and Biogrand at different doses and application timings on plant growth and development parameters, including plant height, stem development, leaf number, and leaf area.

Additional parameters studied included viral disease incidence, tuber formation dynamics, total and marketable yield, seed tuber production, and tuber quality characteristics.

The experiment was conducted under field conditions at the Samarkand Experimental Station of the Scientific Research Institute of Vegetable, Melon and Potato Crops. Minitubers were treated with biological preparations according to experimental variants before planting and sown on March 2–3 using a planting scheme of 70 × 17 cm.

3 Results and discussion

The duration of the growing season of the potato variety Ranemo varied depending on the application of biological preparations. When Biodux was applied at a rate of 130 ml/t for pre-planting tuber treatment, the vegetation period lasted 88 days. In the treatment where tubers were treated before planting and foliar spraying was carried out at the onset of budding at 1000 ml/ha, the growing period was 89 days. Similarly, combined application at pre-planting, pre-budding, and early flowering stages at 1200 ml/ha resulted in a vegetation period of 89 days.

For the Zerebra Agro treatment, application at 200 ml/t before planting, followed by foliar sprays at 250 ml/ha before budding and 300 ml/ha before flowering, resulted in a growing period of 88–89 days. In the case of Biogrand, the vegetation period lasted 89–90 days, whereas the control variant recorded 86 days. Overall, the application of biological preparations extended the growing period by 2–4 days compared to the control.

3.1 Plant Growth and Biomass Development

During the flowering–ripening stage, the application of biological preparations significantly influenced plant biometric parameters. In the Biodux-treated variants, plant height ranged from 81.4 to 82.4 cm, which was 3.4–4.3 cm higher than the control. The number of stems per plant was 2.4–2.5, the number of lateral branches reached 22.6–24.0, and the number of leaves was 56.1–58.0, exceeding the control by 0.4, 3.6, and 3.1 units, respectively. Leaf area was also higher than the control by 0.07–0.13 cm².

A similar trend was observed in the Zerebra Agro treatment, where the highest biometric indicators were recorded when tubers were treated before planting at 200 ml/t and foliar applications were carried out at 250–300 ml/ha during budding and flowering stages. In this treatment, plant height reached 80.7–81.6 cm, stem number 2.6–2.7, lateral branches 24.2–24.9, leaf number 58.1–58.7, and leaf area 0.59–0.60 cm².

3.2 Effect of Biogrand on Growth Parameters

The highest biometric indicators were recorded in the Biogrand-treated variants, surpassing both Biodux and Zerebra Agro treatments. When applied at a rate of 200 ml/t for pre-planting tuber treatment and 1000–1200 ml/ha during budding and flowering stages, plant height reached 83.0–83.2 cm, stem number 2.9–3.0, lateral branches 28.0–28.9, leaf number 66.5–67.4, and leaf area 0.64–0.69 cm².

Compared to the control (no biological treatment), Biogrand increased plant height by 5.1 cm, stem number by 0.9, lateral branches by 7.5, leaf number by 12.5, and leaf area by 0.15 cm².

Furthermore, Biogrand outperformed Biodux and Zerebra Agro treatments, increasing plant height by 0.8–1.6 cm, stem number by 0.4–0.5, lateral branches by 4.0–4.9, leaf number by 8.7–9.4, and leaf area by 0.2–0.9 cm² (Table 1).

Table 1. Productivity of plants in experimental variants.

No	Experimental variants	Application period	Application period	Application period	Productivity, per batch	Productivity, per batch	Productivity, per batch	Productivity, per batch	Productivity, per batch	Productivity, per batch	Productivity, per batch
No	Experimental variants	Pre-planting tuber treatment	Budding stage	Flowering stage	Average root weight (g)	Average haulm weight (g)	Tuber yield per plant (g)	Average number of tubers (pcs)	Average tuber weight (g)	Tuber appearance (score)	Marketability (%)
1	CONTROL	-	-	-	26.0	351.0	503.6	5.9	85.3	7	92.0
2	BIODUX	130ml/t	-	-	30.4	365.7	572.8	6.1	93.9	8	93.5
3		130ml/t	1000 ml/ha		31.3	371.4	596.7	6.2	96.2	8	94.4
4		130ml/t	1200 ml/ha	1200 ml/ha	32.4	371.8	613.0	6.2	98.8	8	94.8
5	ZEREBRA AGRO	130ml/t	1300 ml/ha	1300 ml/ha	32.6	385.4	652.7	6.5	100.4	8	92.6
6		200ml/t	-	-	32.0	364.2	598.1	6.2	96.5	9	94.5
7		200ml/t	200 ml/ha		33.0	364.8	629.5	6.3	99.9	9	96.1
8		200ml/t	250 ml/ha	250 ml/ha	32.8	371.2	697.6	6.8	102.5	9	96.4
9		200ml/t	300 ml/ha	300 ml/ha	33.7	375.3	708.0	6.9	102.6	9	93.8
10	BIO-GRAND	200ml/t	-	-	31.9	375.2	727.4	6.8	106.9	8	94.6
11		200ml/t	1000 ml/ha		32.4	376.4	729.3	6.9	105.7	9	95.7
12		200ml/t	1000 ml/ha	1000 ml/ha	32.7	385.9	740.0	7.0	105.7	8	96.3
13		200ml/t	1200 ml/ha	1200 ml/ha	33.1	391.2	755.0	7.0	107.8	7	94.0

In the study, the degree of root system development in plants was investigated. Root weight and root volume were determined, and root productivity (defined as the ratio of root weight to root volume) was analyzed. Depending on the type, application rate, and timing of the biological preparations, the highest values were recorded in the Biogrand-treated variants.

When Biogrand was applied at a rate of 200 ml/t before planting and 1000–1200 ml/ha during the budding and flowering stages, the following results were obtained: during the budding stage, root weight reached 22.8–23.8 g, root volume 24.1–25.3 cm^3, and root productivity 94.0–94.2%. During the flowering stage, root weight increased to 32.7–33.1 g, root volume to 39.3–40.4 cm^3, and root productivity ranged between 81.9–83.2%.

Compared to the control, root weight during the flowering stage increased by 7.1 g, and root volume by 8.6 cm^3. Compared to Biodux and Zerebra Agro treatments, Biogrand resulted in higher root weight by 0.5 g and root volume by 1.6–5.1 cm^3.

3.3 Viral Disease Incidence

The incidence of viral diseases (X, Y, S, and M viruses) was assessed in plant leaves using specific antisera at different canopy levels during the budding and flowering stages. In the control variants, infection levels reached 2.9–4.0% during the budding stage and 3.5–6.5% during the flowering stage. In contrast, in the variants treated with biological preparations, infection rates were lower, ranging from 2.9–3.0% (budding stage) and 4.0–4.2% (flowering stage).

3.4 Effect on Plant Productivity

The study also evaluated plant productivity indicators, including root weight, haulm weight, average number of tubers per plant, average tuber weight, tuber appearance, marketability, and yield formation per plant.

In the Biodux-treated variants, the highest productivity was achieved when tubers were treated before planting at 130 ml/t and foliar spraying was conducted during the budding and flowering stages at 1200–1300 ml/ha. Under these conditions, root weight reached 32.4–32.6 g, haulm weight 371.8–385.4 g, average number of tubers 6.2–6.5, average tuber weight 98.8–100.4 g, appearance score 8, and marketability 94.4–94.8%.

In the Zerebra Agro-treated variants, the highest results were obtained when tubers were treated before planting at 200 ml/t and foliar applications were carried out at 250–300 ml/ha during budding and flowering. Root weight reached 32.8–33.7 g, haulm weight 371.2–375.3 g, tuber number 6.8–6.9, average tuber weight 102.5–102.6 g, appearance score 8–9, and marketability 93.8–96.4%.

The highest overall productivity indicators were observed in the Biogrand-treated variants, where tubers were treated at 200 ml/t before planting and foliar applications were carried out at 1000–1200 ml/ha during the budding and flowering stages. Root weight reached 32.7–33.1 g, haulm weight 385.9–391.2 g, tuber number 6.9–7.0, average tuber weight 105.7–105.8 g, appearance score 7–8, and marketability 94.0–96.3%.

3.5 Optimal Treatment Recommendation

Based on the type of biological preparation, application timing, and dosage, the most effective treatment was identified as Biogrand. The optimal application method involves pre-planting tuber treatment at 200 ml/t (either by spraying or soaking in the working solution for 30 seconds), followed by foliar application at 1000–1200 ml/ha during the budding and early flowering stages. This approach ensures optimal plant growth, development, and increased productivity.

3.6 Yield Performance

In the control variant (without biological preparations), the average yield of the Ranemo potato variety was 27.1 t/ha.

When Biodux was applied only before planting at 130 ml/t, yield increased to 31.6 t/ha, while application during the growing season at 1200–1300 ml/ha resulted in yields of 34.1–35.5 t/ha.

For Zerebra Agro, pre-planting treatment at 200 ml/t resulted in a yield of 32.2 t/ha, and application during the growing season at 250–300 ml/ha increased yield to 34.5–36.4 t/ha.

The highest yields were recorded in the Biogrand-treated variants: pre-planting treatment at 200 ml/t resulted in 32.3 t/ha, while foliar application during the growing season at 1000–1200 ml/ha increased yield to 37.6–37.8 t/ha.

These results exceeded the control by 10.5–10.7 t/ha, and were 1.4–2.3 t/ha higher compared to other biological preparations (Table 2).

Table 2. Yield performance of experimental variants (2023–2025).

No	Experimental variants	Application periods	Application periods	Application periods	Yield, t/ha	Yield, t/ha	Yield, t/ha	Yield, t/ha	Yield, t/ha	Yield, t/ha	Yield, t/ha
No	Experimental variants	Pre-planting (ml/t)	Budding stage (ml/ha)	Flowering stage (ml/ha)	By repetitions	By repetitions	By repetitions	Total	Average (t/ha)	Difference vs control (+/–)	%
No	Experimental variants	Pre-planting (ml/t)	Budding stage (ml/ha)	Flowering stage (ml/ha)	2023	2024	2025	Total	Average (t/ha)	Difference vs control (+/–)	%
1	CONTROL	-	-	-	26.6	26.9	27.8	81.0	27.1	-	
2	BIODUX	130 ml/t	-	-	32.0	30.5	31.0	93.5	31.6	+4.5	16.6
3		130 ml/t	1000 ml/ha		31.9	33.4	32.6	97.9	32.6	+5.5	20.2
4		130 ml/t	1200 ml/ha	1200 ml/ha	34.6	35.0	32.7	102.3	34.1	+7.0	25.8
5		130 ml/t	1300 ml/ha	1300 ml/ha	34.7	36.1	35.8	106.6	35.5	+8.4	33.3
6	ZEREBRA AGRO	200 ml/t	-	-	32.3	33.0	31.4	96.7	32.2	+5.1	15.8
7		200 ml/t	200 ml/ha		33.5	34.6	32.9	100.1	33.6	+6.5	19.4
8		200 ml/t	250 ml/ha	250 ml/ha	35.0	34.7	33.9	103.6	34.5	+7.4	21.4
9		200 ml/t	300 ml/ha	300 ml/ha	35.9	36.2	37.1	109.2	36.4	+9.3	25.5
10	BIO-GRAND	200 ml/t	-	-	31.5	32.4	33.0	96.9	32.3	+5.2	16.0
11		200 ml/t	1000 ml/ha		35.2	33.1	34.9	103.2	34.3	+7.2	20.9
12		200 ml/t	1000 ml/ha	1000 ml/ha	36.0	38.8	38.0	112.8	37.6	+10.5	27.9
13		200 ml/t	1200 ml/ha	1200 ml/ha	38.2	36.7	39.3	113.5	37.8	+10.7	28.3

4 Conclusion

In conclusion, the appropriate selection and application of the biologically active preparation Biogrand plays a crucial role in improving the growth, development, and productivity of potato varieties. When potatoes are planted at early dates, the application of Biogrand at a rate of 200 ml/t for pre-planting tuber treatment, combined with foliar application at 1000–1200 ml/ha during the budding and early flowering stages, ensures optimal plant growth and development, leading to significantly increased productivity and yield.

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