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Original Research Paper

Effect of the Biological Preparation Phytop 8.67 on the Quality and Yield of Rice in Saline Soils

[1]Nurzhan Ybraikozha, [2]Asset Toktamysov, [3]Elvira Sagindykova, [3]Laura Bissenova, [1]Elmira Eleuova, [4,5]Aliya Bugubaeva, [4]Almabek Nugmanov, [5,6]Gulzada Ekibaeva, [4]Vadim Chashkov and [4]Assel Tokusheva

[1]Kyzylorda University named after Korkyt Ata, Kazakhstan
[2]Kazakh Research Institute of Rice Growing named after I. Zhakhaev, Kazakhstan
[3]Caspian University of Technology and Engineering named after Sh. Yessenov, Kazakhstan
[4]A. Baitursynov Kostanay Regional University, Kazakhstan
[5]Faculty of Soil Science, Lomonosov Moscow State University, Russia
[6]Department of Natural Sciences, Yessenov University, Kazakhstan

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Corresponding Author:
Aliya Bugubaeva
A. Baitursynov Kostanay Regional University,
Kazakhstan
Email: alia-almaz@mail.ru

Abstract: Phytop 8.67 is a modern biological multifunctional preparation that has a complex effect on cultivated plants, harmful organisms, and soil. The study aimed to evaluate the effect of the biological preparation Phytop 8.67 on increasing yields and improving the quality of rice grains. Rice of the Marzhan variety growing on meadow/marsh rice soils was studied. The use of phytop 8.67 proved to be an effective method of increasing the productivity of rice culture in saline soils of the Kazakhstan Aral Sea region. The productivity of rice with three-time uses in the phases of vegetation in the production experiment increased by 25-30% compared to the control variants. In the field, the biological preparation provided an increase in grain yield from 20.0-25.3 c/ha. The increase in rice yield was due to the improvement of the elements of the crop structure. Pre-sowing treatment of seed material contributed to an increase in seed germination and greater plant viability by the end of the growing season. In the tillering phase, the tilling capacity of rice increased up to 2.2 times, as well as the length and the number of grains per ear of the main panicle and the weight of grain from one plant.

Keywords: Biological Preparations, Phytop 8.67, Ammonium Sulfate, Vegetation Phases, Rice Yield, Crop Structure

Introduction

In the context of the widespread introduction of chemicals, increased investment in agriculture, and state support for agricultural producers, it is of great importance to solve the problem of increasing the economic efficiency of mineral fertilizers, reducing their losses and related issues of environment protection and human health (Artemyev *et al*., 2019; Suraganova *et al*., 2022).

As a result, the application of mineral fertilizers of biological origin, where the most important are the latest micro fertilizers, provides at least half of the resulting total yield growth (Dzhamantikov *et al*., 2018; Toktarbekova *et al*., 2020; Ivanov *et al*., 2021).

The introduction of mineral fertilizers of organic origin contributes to an increase in the production of high-quality agricultural products and allows, along with a sharp increase in the gross yield, to reduce the unit cost by 30-50% (Polushkina *et al*., 2020; Suraganova *et al*., 2022).

Organic fertilizers contain nitrogen, phosphorus, potassium, calcium, and other plant nutrients, as well as organic matter, which positively affects the properties of the soil. Organic fertilizers consist of substances of animal and plant origin, which, decomposing, form mineral substances, while carbon dioxide necessary for plant photosynthesis is released into the surface layer (Zubkova *et al*., 2022). Besides that, organic fertilizers have a beneficial effect on the water and air nutrition of plants, contribute to the development of soil bacteria and microorganisms that have a symbiotic relationship with the roots of vegetable crops, and help them receive available nutrients. Organic fertilizers include manure, peat, compost, bird droppings, humus, and other materials. The stimulating effect of organic fertilizers is significantly increased if they are applied in the form of fine powder (Darch *et al*., 2019; Salkhozhayeva *et al*., 2022).

In modern agriculture, complex stress received by cultivated plants from the action of unfavorable environmental factors is an acute problem. Among them, one can name soil/climatic (including the stress associated with global warming processes), weather, biotic (phytopathogens, pests, weeds), and anthropogenic (intensive exploitation of soils, crops, and plantings, environmental pollution) stress (Bekezhanov *et al*., 2021).

The trend of biologization of agriculture outlined in the last decade aimed both at preserving the natural fertility of the soil and obtaining environmentally friendly products in crop production requires the widespread use of biologically active substances of natural origin that have a complex effect with fungicidal, bactericidal and phyto-regulatory (growth-regulating and anti-stress) properties. The low cost of such highly effective biological fertilizers makes them attractive for use as growth stimulants, micronutrients, plant protection products, and antidepressants (Nasiyev *et al*., 2022).

Rice is a demanding culture concerning mineral nutrition. In all countries of the world where rice is cultivated, on almost all types of soils, this crop responds positively, first of all, to the application of nitrogen fertilizers (Zhumatayeva and Toktamyssov, 2017; Yulita *et al*., 2021). When using biological preparations for rice, plants till out better, their carbohydrate-protein metabolism improves, and the speed, direction, and quality of organogenesis change (Hong *et al*., 2021).

An increase in the yield of rice grains is inextricably linked with the creation of optimal conditions for the nitrogen nutrition of plants by applying nitrogen fertilizers (Chivenge *et al*., 2021). Existing developments for optimizing the nitrogen nutrition of rice have significant drawbacks associated with the need to apply nitrogen fertilizers several times during the growing season, which is very expensive and is not compensated by a slight reduction in fertilizer consumption (Hakeem *et al*., 2012).

In field experiments with rice culture, the determination of the utilization rate of nitrogen fertilizers using the isotopic method showed that it was very low, in the range of 19-20%. The low nitrogen utilization rate in fertilizers applied to rice is primarily due to high nitrogen loss during rice cultivation. This loss can occur due to the volatilization of ammonia from the soil, the formation of gaseous nitrogen compounds, as a result of nitrification, biological and chemical denitrification, and the leaching of nitrates into the lower horizons of the soil or groundwater (Hakeem *et al*., 2011; Alfi *et al*., 2019).

Currently, the effectiveness of the use of the phytop 8.67 biopreparation on rice is poorly studied. According to Ybraikozha *et al*. (2023), the yield of rice of the «Syr Suluy» variety increases during presowing seed treatment and fertilizing with biological preparations nacle and phytop 8,67 and when used together with full mineral fertilizer.

The study aimed to evaluate the effect of phytop 8.67 on increasing yields and improving the quality of rice grains.

Materials and Methods

The research was carried out in 2017 during the agricultural year using phytop 8.67 in field and production conditions on the territory of the Karauyltobe experimental farm of the Kazakh Research Institute of rice growing named after I. Zhakhaev. Field and production experiments were established on the territory of the field of the second crop rotation of the Karaultyubinsky testing station of the Kazakh Rice Research Institute named after I. Zhakhaev, located 10 km northeast of the city of Kyzylorda.

The object of the study was a new biological multifunctional preparation phytop 8.67 and the marzhan rice variety of Kazakhstan selection approved for use, which annually occupies 25-30% of the total area of rice fields in the region. Phytop 8.67 is a modern biological multifunctional preparation. It has a complex effect on cultivated plants, harmful organisms, and soil. Phytop 8.67 has the following properties:

- It stimulates the growth of the root system, the aboveground part, and the total biomass of plants
- It suppresses plant pathogens
- It increases the activity of soil microflora, cleanses the soil of pathogenic microbes, and increases its fertility
- It increases the stress resistance of plants' winter hardiness, drought resistance
- As a result, it increases productivity up to 25-30%

The composition of the preparation includes in equal proportions three strains of saprotrophic bacteria: *Bacillus subtilis* VKPM B 10641, *B. amyloliquefaciens* VKPM B 10642 and *B. amyloliquefaciens* VKPM B 10643 from the collection of the research center research and Production Company (NPF) Limited Liability Company (LLC), isolated in ecologically clean areas of Siberia.

From the day of sowing rice seeds during the growing season, work was carried out on plant care, observing the technology of culture cultivation, and conducting research under the pre-planned program.

To determine the state of the soil at the experimental site, soil samples were taken from the arable layer before sowing. Besides that, to determine the dynamics of mobile forms of nutrients during the growing season, agrochemical soil analyses were carried out; plant analyses were also carried out to determine the assimilation and removal of nutrients by rice plants. Wastewater samples were analyzed to determine the loss of nutritional elements. Modern methods of chemical analysis were used in the study.

Soil analysis:

- Determination of humus using the method developed by I.V. Tyurin (year) and modified by V.I. Simakov (year)

- Determination of total nitrogen using the Kjeldahl method
- Determination of phosphoric acid using the Lorentz method (total phosphorus)
- Determination of mobile forms of phosphorus and potassium in soils using the Machigin method

In the production fields on the crops of the zoned Marzhan rice variety, experiments were established to determine and establish the effectiveness of phytop 8.67. Studies were conducted on several treatments with pre-sowing seed treatment and foliar top dressing with phytop 8.67 preparation of rice culture in the growing phases. The area of production experiments was 14 ha.

The collection of materials on observations of the meteorological conditions of the experimental zone for the growing season (data from the weather station of Kyzylorda) was carried out. Phenological observations of the growth and development of rice plants according to the variants of the experiment were carried out and the dates of the onset and completion of the phenophases were noted. The beginning of the vegetation phase was considered to be the date at which 10% of the available plants on plots (in vessels) entered this phase and the full onset of the phase was considered when 75% of plants entered it.

The agricultural technique of the study: Preceding crop: Perennial grasses; tillage: Winter mouldboard plowing to a depth of 22-24 cm; early spring disk tillage with BDT-7.0, leveling the rice bay surface with a long-span leveler, repeated winter plowing to a depth of 16-18 cm, disk tillage with BDT-7.0, tandem disk harrowing with BZTU-1, rolling with ZKK-6 ring rollers.

The field experiment with two variants was established in the optimal time of rice sowing for this zone of the Kyzylorda region, at the production site in compliance with all agricultural techniques and principles of field experiment establishment (Fig. 1).

After careful mechanical tillage of the experimental site, pre-sowing doses of mineral fertilizers, including nitrogen fertilizers, were introduced into the arable soil layer. The embedding was carried out by mixing the surface layer with BDT-3 disk harrows. After sowing rice seeds with a seed drill, the rice bay was immediately flooded to avoid gaseous nitrogen loss. From that moment, the rice vegetation began.

Besides, during the growing seasons in the development of rice, foliar fertilization with phytop 8.67 preparation was carried out in the phases of rice tillering and earing in doses of 10 mL per 1 ha.

During the period, work was carried out including plant care and observing the water regime for rice in field and production experiments, following the technology of cultivation of the studied culture.

(a)

(b)

(c)

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(d)

Fig. 1: Fragments of the work on the field experiment establishment; (a) Mechanical tillage of the test site; (b) Preparation of the test site; (c) Rice in the earing phase; (d) Selection of plant samples for analysis

Crop accounting in the field experiment was carried out separately, the yield data were processed using the method of variance analysis according to Dospekhov (2011). Statistical analysis of data was performed using StatTech v. 3.1.6 (stattech LLC, Russia). Quantitative variables following a normal distribution were described using Mean (M) and Standard Deviation (SD), 95% confidence interval (95% CI) for the mean was estimated.

Results

Soil and Climatic Characteristics of the Zone and Meteorological Indicators

The climate of the Kyzylorda region is continental, with hot dry summers and cold winters with unstable snow cover. The average annual air temperature is 9.8°C. The climate of the region is very arid. The average annual precipitation is 129 mm. In some dry years, only 40-70 mm of precipitation falls. The soil of the experimental site is meadow/swamp, typical for rice crop rotations of the region. It is characterized by a low humus content of up to 1%, reduced porosity, and a fairly high value of dissolved solids (0.6-0.8%). The type of salinity is sulfate, medium saline. The soil characteristics of the experimental site are presented in Table 1.

The winter turned out to be abnormally warm and the deviation from the norm reached record levels of 6°C. The aforementioned months had never been so warm in the region (Table 2). As a result of the abnormally early development of spring processes and very warm weather, already in the third decade of March, the mechanically heavy rice soils dried out to a moderately moist state, which made it possible to begin fieldwork. That year, sowing began about a month earlier than the usual term. The pace of sowing was much higher than the previous year. The agrometeorological conditions for spring field work were favorable. However, it should be noted that during the sowing work and the emergence of seedlings, unfavorable conditions developed caused by an unstable temperature regime, when on some days there was a sharp drop in the daytime and nighttime air temperatures up to 20°C.

The summer months (June, July, and August) were characterized by very hot and exceptionally dry weather. Since the beginning of June, the average daily air temperature has been higher than the long-term average value.

Biological Yield of Rice Culture when Using Phytop 8.67

The analyses showed that seed treatment and foliar top dressing in the vegetative phases of rice with phytop 8.67 increased the yield of rice in the experiments to 89.5 c/ha (Table 3).

Table 1: Soil characteristics of the experimental site, 2017

Horizon, cm	pH	mV	Dissolved solids, %	Anions, %/mg equivalent in 100 g of soil				Cations, %/mg equivalent in 100 g of soil			Total amount of salts, %	Type of salinization
				CO_3	HCO_3	Cl	SO_4	Ca	Mg	Na		
0-20	7.64 slightly alkaline	-24	0.8	0	0.027	0.018	0.576	0.17	0.046	0.016	0.853	sulfate medium saline
				0	0.450	0.500	12.000	8.50	3.750	0.700		
20-40	7.55 slightly alkaline	-19	0.6	0	0.021	0.018	0.600	0.17	0.046	0.025	0.880	sulfate medium saline
				0	0.350	0.500	12.500	8.50	3.750	1.100		

Table 2: Meteorological conditions characteristics, 2017

Month	2017 agricultural year					
	Average daily air temperature, °C			Precipitation, mm		
	Average monthly	Average long-term	+, - To the average long-term	Per month	Average long-term	+, - To the average long-term
1	2	3	4	5	6	7
September	19.35	18.6	+0.50	1.0	4	-0.50
October	9.30	10.2	-0.90	14.0	10	+4.00
November	3.00	1.9	+1.10	29.0	17	+12.00
December	0.60	-4.7	+5.3 (a record)	39.0	17	+22.00
January	-1.00	-6.8	+5.8 (a record)	33.0	19	+14.00
February	1.90	-5.0	+6.9 (a record)	2.0	15	-13.00
March	9.30	2.7	+6.60	20.0	17	+3.00
April	15.60	13.3	+2.30	27.6	16	+11.60
May	21.05	20.3	+0.75	13.9	16	-2.05
June	25.10	26.1	-0.90	13.3	10	+3.30
July	27.90	27.8	+0.15	0.0	6	-6.00
August	25.60	25.5	+0.26	1.1	4	+0.60
For the agricultural year	11.0	11.7	+2.50	198.0	151	+36.95

Table 3: The resulting values of the biological yield of rice after the use of Phytop 8.67

Variant	Yield, c/ha			
	I	II	III	Average
Phytop 8.67 (seed treatment, foliar top dressing)	89.5	88.9	89.2	89.2±0.3
Control	64.2	61.2	60.0	61.8±2.2

According to biometric analysis on the control variant, the productive tilling capacity was 2.7, the length of the main panicle was 17.7, the number of grains on the main panicle equaled 84.5, the grain weight was 2.6 and the number of grains from 1 plant was 107.5. In the variant with Phytop 8.67, the productive tilling capacity was 3.5, the length of the main panicle was 20.9, the number of grains on the main panicle was 106.6, the weight of the grain was 3.6 and the number of grains from 1 plant was 169.6.

Discussion

The results showed that the most effective methods of applying phytop 8.67 were pre-sowing seed treatment and foliar top dressing in the phases of tillering and earing of rice (Table 3). This is explained by the fact that this micro fertilizer stimulates the growth of a powerful root system of the aboveground mass of rice plants. This provides a fairly significant increase in yield.

Rice cultivation in the lower reaches of the Syrdarya River performs the reclamation function for saline irrigated agricultural lands, occupying up to 90 thousand ha annually (Funakawa *et al*., 2000; Duan *et al*., 2022). The use of phytop 8.67 and the development of technology for its application for rice will save the cost of its application, and reduce the rate of application of nitrogen fertilizers and the environmental burden on the ecosystem. By increasing the yield of rice and reducing the cost of purchasing and using fertilizers, the cost of production (rice grain) will decrease by half.

Increasing the yield of the rice grain is inextricably linked with the creation of optimal conditions for plant nutrition by applying mineral fertilizers to the soil (Hakeem *et al*., 2012; Kongpun and Prom-u-Thai, 2021). With the modern technology of applying mineral fertilizers for rice in the Kazakhstan Aral Sea region, rice uses no more than 20% of the nitrogen fertilizers applied and the rest is lost as a result of the formation of gaseous nitrogen products due to biological and indirect denitrification, as well as as a result of leaching of nitrates from the root layer, adding to the environment pollution.

Increasing the efficiency of mineral fertilizers in rice cultivation with the help of humic acids makes it possiblea to improve the ecological condition of irrigated lands, increase the yield and quality of rice crop products, and save several tens of thousands of tons of technical nitrogen that enters the market of Kazakhstan from neighboring countries.

Conclusion

The productivity of rice with three-time fertilization in phases in the production experiment with the use of the biological multifunctional preparation phytop 8.67 increased by 25-30% compared with the control in the field, the preparation provided an increase in grain in addition to the background conditions from 20.0-25.4 c/ha.

The increase in rice yield was due to the improvement of the elements of the crop structure. Pre-sowing treatment of seed material contributed to an increase in seed germination and greater plant viability by the end of the growing season. The use of this preparation in the tillering phase in the field experiment increased the productive tilling capacity of rice up to 2.2 times, as well as the length and grain size of the main panicle and the weight of grain from one plant.

In this research, only the Marzhan rice variety was studied. Further research should be aimed at studying the effect of phytop 8.67 on other rice varieties.

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Author’s Contributions

All authors equally contributed to this study.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues are involved.

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