The Influence of NacLee Biological Fertilizer, Fitop 8.67 Preparation, and Mineral Fertilizer to the Crop Yield of Rice in Kazakhstan Aral Sea Region

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Abstract

Bio-fertilizers are becoming more and more popular in many countries and for many cultures, but there are too few researches of their influence to crop yield concerning rice. Therefore we have assessed 2 different bio-preparations at the Aral Sea region during four agricultural seasons between 2016 and 2019. The experiments were held in fully irrigated conditions in the typical lowland rice environment. The article contains the results of the research in the use of complex liquid fertilizers and biological preparations. The purpose of the researches is the use of complex liquid fertilizers and biological preparations and the analysis of agro-ecological effect on rice growth in the conditions of the Aral Sea region. We have conducted field experimental studies to determine the agro-ecological efficiency of the use of complex liquid fertilizers and biological preparations and their influence on increasing the rice crop yield.

Introduction

The main and strategic task of the agro-industrial complex of the Republic of Kazakhstan is increase in production of grain and provision of the national food security. Therefor the accelerated development of the grain economy and diversification of crop raising are the high priority tasks of the national agro-industrial complex. The main lines of agricultural development in conditions of the main rice-growing area – Kazakhstan Aral Sea region – are sustainable development of rice-raising and increase of rice crop yield. [Dobbelaere S, Vanderleyden J, Okon Y (2003), Bhattacharyya, P.N., and D.K. Jha. 2012, Biswas, J. C., J. K. Ladha, F. B. Dazzo, Y. G. Yanni, and B. G. Rolfe. 2000.]

Rice is an ancient culture of the Asian continent and an important food culture of the world. This culture is raised in 112 countries at the area of over 147 million ha, and the gross yield of grain in the last decades has been over 750 million ton. According to the forecast calculation made by the UN specialists, the gross yield of grain will increase by 7% by 2025 and will reach 780 million ton. That’s why the main food product for 4.6 – 5.0 billion people in the world will be rice grain; their well-being and sustainable demographic growth depends on increase of grain crop yield. Rice is raised in regular agricultural conditions and, therefore the grain crop yield can be significantly increased. Thanks to support being provided for rice selection and genetics by the governments of many countries of the world, currently there are high-yield, intensive sorts bred and introduced into production. Through the use of complex, integrated rice growing technology and its strict observance in conditions of Australia and Egypt, the average grain crop yield reached 102.9; 93.7 hundred kg/ha, in USA – 81.1 hundred kg/ha, Turkey – 79.3 hundred kg/ha, in China 65 – 68hundred kg/ha (at the area over 32 million ha). However, in many countries, including Kazakhstan Aral Sea region, such a high rice crop yield cannot be easily reached on a vast territory [Bottini, R., F. Cassán, and Piccoli, P. Gibberellin. 2004., Bockman OC, Kaarstad O, Lie OH, Richards I (1997)].

Due to drying out of the Aral Sea, deterioration of the environmental conditions of the Aral Sea region, increase of Syr-Darya river water mineralization and ground water rise because of poor drain and waste systems operation, the soil resalinization is increasing. The meadow-boggy soils have transformed into medium and highly saline soils and solonchaks. At the same time, not only geophysical and meteorological conditions have changed, but also biological and ecological balances have been disturbed. In Kyzylorda region, 80-85% out of 217 thou. ha of developed irrigated land are medium and highly saline, and 60 thou. ha have been withdrawn from agriculture and are not used due to salinity and bogginess.

Rice is an environmentally beneficial, strategically crucial culture and the economical basis for rice-planting economies. According to the scientifically grounded standards of the Institute of Nutrition of the National Academy of Science, the Republic of Kazakhstan (8.5kg per person), the necessary amount of rice in the Kazakhstan domestic market is 132.6 thou. ton. The rice-planting economies of Kyzylorda region significantly contribute to provision of the Kazakhstan population with rice grain, but at the same time, in 2017 – 2019, the export of rice increased by 28%.

However, the current critical ecological situation in Kazakhstan Aral Sea region forces rice growers to reduce the area of irrigated land occupied by rice. That's why increase of rice crop yield is a relevant task. Solution of this problem is associated with profound and comprehensive study of the role of micronutrient fertilizers in the rice fertilization system in conditions of Kazakhstan Aral Sea region. In 2018, the scientists from the Kazakhstan I. Zhakhayev Rice-Growing Scientific Research Institute and Kyzylorda Korkyt-Ata State University conducted a study of the modern rice mineral nutrition technologies based on the use of soil, water, and plants diagnostic methods in Karaultobe experimental production farm in Kyzylorda region.

Nitrogen (N) is the main nutritious substance necessary for growth and development of plants. The search of environmentally friendly and cost efficient substitute for nitrogenous fertilizers is currently focused on endophytic diazotrophic bacteria, which, supposedly, are responsible for provision of biologically bound nitrogen N. Conceptually, endophytic bacteria improve plants growth, directly or indirectly, by lowering the level of ethylene in plants with the help of aminocyclopropane carboxylate (ACC) desaminase or by release of the main nutritious substances, such as N, P, Fe etc [Vessey, J.K. (2003), Hakeem KR, Ahmad A, Iqbal M, Gucel S, Ozturk M (2011)]

The necessity to prevent stresses and diseases requires improving of the fundamental processing methods aimed at creation of conditions for the best possible satisfaction of the biological demands of cultivated plants, as well as effective methods that allow controlling the processes of their growth, development, and immunity forming. There is much concern about preservation and recovery of soil fertility in conditions of intensive plant-growing technologies, frequently leading to ecological destabilization of farming ecosystems and, as a consequence, to economic instability [Dobbelaere S, Vanderleyden J, Okon Y (2003)].

Biological preparations and micronutrient fertilizers for plant protection are an environmentally safe alternative to chemical (synthetic) pesticides. Substitution of chemical pesticides with bio-preparations in agriculture and forest husbandry goes on not as quickly, as one can expect. In particular, this is due to the fact that product manufacturer like the speed and wide spectrum of chemicals effect.

As a rule, bio-fertilizers contain non-symbiotic organisms bound to the root surfaces, but they can also include endophytes, microorganisms that are capable of colonizing intercellular or even intracellular compartments of plant tissue without causing visible damage of the host plant. The concept of bio-fertilizers was developed based on the observation showing that microorganisms can have a beneficial effect on plants and crop yield growth.

The multiannual field and production experiments on testing these micronutrient fertilizers on grain cultures, potatoes, vegetable, fruit, berry, and flower cultures, held by scientists and manufacturers in different natural areas of Kazakhstan and abroad (Italy, Spain, China, Russia, Turkey, Vietnam) demonstrated the effects of stimulating the length and biomass of the root system to 15-20%, total biomass of plants to 20-25% and more, increase of crop yield to 20-30%. They improve plant survival in drought and eliminate shock status after zero tillage. It has been proved that there is a possibility to immunize treated plants and subsequently reduce the affection rate of

various plantations with a number of infections transferred with seeds, through the soil, and by airborne transmission[Hakeem KR, Chandna R, Ahmad A, Iqbal M (2012a), Kennedy IR, Cocking EC (1997)].

In view of this, in 2016-2019 studies using the data of micronutrient fertilizers and preparations were held in field conditions at the premises of the Kazakh I. Zhakhayev Scientific Research Institute of Rice Growing.

In production fields, in plantations of recognized rice varieties “Marzhan” and “Yantar”, experiments on determination of the effectiveness of biological liquid micronutrient fertilizers NacLee and Fitop 8,67 were held. The studies were conducted in several variants with pre-sowing seed treatment, top dressing of the rice cultures during vegetation. The area of production experiments covered 14 ha. Accounting and observations in the experiments were held according to the commonly used methods.

The biological preparation *Fitop 8.67* is the modern biological multifunctional preparation. It has a complex effect on cultivated plants, harmful organisms, and soil.

The preparation contains in equal proportion 3 strains of saprotrophic bacteria: *acillus subtilis* ВКПМ В 10641, *B. amyloliquefaciens* ВКПМ В 10642, *B. amyloliquefaciens* ВКПМ В 10643 from the collection of ООО Research and Production Company «Research Centre» produced in environmentally clean regions of Siberia and selected by authors-developers.

Fitop 8.67 has the following properties:

- stimulates growth of the root system, aerial portions, and total plant biomass;

- eliminates causative agents of plant diseases;

- increases the activity of soil microflora, purifies soil of disease causing microbes and improves its fertility;

- improves tolerance of plants to stress – winter and drought hardiness;

- as a result, it increases crop yield to 25-30%.

When bacilli in Fitop 8.67 are placed on a plant surface or into soil, they get involved into the rhizospheric and epiphytical plant microflora; there happens a certain modification of the environment, good both for the plant health, and for the health of animals and people that eat plant food.

The biological fertilizer Nacle is an environmentally safe liquid fertilizer –aimed at preservation and protection of the nature and ecosystem without causing harm to wild birds and animals. It has a lot of advantages, including soil nutrition and root dressing, which facilitate well-balanced growth, development of plants, and excellent fertilization and blooming. This is a natural, active, high concentration liquid fertilizer of absolutely new quality that allows increasing agricultural crop yield and the quality of various plants productivity.

Materials And Methods Of Study

In our studies we performed pre-sowing treatment of seeds with NacLee at a dose of 1l and Fitop at a dose of 2ml per ton of rice seeds, which significantly affected the power and survival of rice roots. In experimental variants with Fitop and NacLee compared to the control plants, the root length increased 1.5 times.

Also, during rice vegetation, we did top dressing with these micronutrient fertilizer and preparation during the tillering and heading phase of rice at a dose of 2l of NacLee and 1ml of Fitop per 1 ha, correspondingly.

The analyses showed that seed treatment and top dressing during rice vegetation with NacLee and Fitop 8.67 gave the rice yield in the experiments of 89.2 hundred kg/ha and 82.4 hundred kg/ha, correspondingly.

We have determined the factors that deteriorate mineral nutrition of rice and decrease rice yield and grain quality:

- we have determined soil and irrigation water saline level (according to vegetation phases).

- we have determined the degree of stress factors influence (salinization, high temperatures, herbicide toxicity) on the physiological and biochemical processes in plant tissues and forming of rice plant productivity elements;

- we have determined the necessity to correct rice mineral nutrition during vegetation (seed treatment and top dressing).

In our studies we also used an organo-mineral fertilizer and tried to determine the effect on rice yield.

MicroCat Cereal Start during rice tillering and **Kelik K + Si** during stem elongation.

Rice is the most silicophilous agricultural plant; it contains up to 11% of silicon. Rice crop annually removes about 750 kg/ha of the available silicon earth, grain crop – 120kg/ha, beans – 10kg/ha, potatoes – 8kg/ha. Consequently, soil annually gets impoverished with available silicon earth, which leads to its degradation.

Silicon increases leaf colour intensity, leaf area, photosynthesis activity and accumulation of dry substance, and also silicon improves immunity against diseases. That's why **Kelik K + Si** is a unique fertilizer containing potassium and silicon in chelate form.

MicroCat Cereal Start contains a vitamin complex; it is the newest preparation that has no analogues in the range of its effect on plants. The complex of macro- and microelements accelerates seed germination, enhances the root mass and provides a plant with the necessary nutrition in its critical phases.

The field experiments were held at the rice irrigation system of the Kazakh I. Zhakhayev Scientific Research Institute of Rice Growing. Rice was sown with a nursery planter by row planting method with seed placement depth being 2-3cm., seeding application rate is 7.5 million germinable seeds per hectare. Background – alfalfa. Fertilizer $N_{45}P_{60}K_{30}$ kg/ha of active substance. Irrigation mode – shortened flooding. Plot area 50m^2, triple replication. Plots layout – systematic. Rice sort – Syr Suluyi.

The seeds were treated immediately before sowing by semidry method – 1l per 3 tons of seeds. Top dressing was performed during the tillering phase with MicroCat Cereal Start with a rate being 1 l/ha with process fluid 25 l/ha, and Kelik K + Si during stem elongation with a rate being 1l/ha with process fluid 25 l/ha.

The biometric analysis was performed by sampling of 10 plants from each experimental plot before harvesting. Accounting of the crop by harvesting a record plot with subsequent threshing and weighing. The obtained results were assessed by the method of analysis of variance.

Results And Discussion

Forming of the cultivated plant crop is to the critical extent determined by productivity of photosynthesis as the main physiological process in the plant organism. The intensity of this process directly depends on leaf surface area, their quantity, and assimilating activity.

The studies conducted showed that the largest area of rice leaves was seen during rice ear emergence, irrespective of the dose and method of fertilizer MicroCat Cereal Start and Kelik K+Si application.

Before this phase, dieback of old leaves and forming of new ones goes on with the latter process prevailing. After ear emergence, when all the leaves have been formed, the assimilating area reduces.

The use of MicroCat Cereal Start and Kelik K+Si did not change the character of the above-mentioned dynamics, but influenced the quantitative indices. Thus, during ear emergence, the leaf surface of the treated plants formed in a bigger amount than in the control group. Top dressing of plants with MicroCat Cereal Start and Kelik K+Si in the tillering and ear emergence phase, slowed down dieback of the leaves, which is supported by the data concerning assimilation area in the milky-wax ripeness phase of grain.

When comparing the effectiveness of top dressing with the control group, which was not treated, it should be noted that the advantage of top dressing is confirmed by forming of the largest assimilation area of leaves and accumulation of plastid pigments, reduction of blind-seed disease, and increase of grain mass obtained from a plant.

Table 1 – Accounting results for the biological crop yield of rice when using liquid biological micronutrient fertilizers NacLee and Fitop 8,67

Variant	Crop yield, hundred kg/ha			
	I	II	III	Average
Control group	64.2	61.2	60.0	61.8
NacLee (seed treatment, top dressing)	82.0	82.8	82.3	82.4
Fitop 8,67 (seed treatment, top dressing)	89.5	88.9	89.1	89.2

The rice yield under the influence of this biological fluid micronutrient fertilizer and the preparation was mainly associated with higher preservation of the plants and improvement of productive plant stand, increase of 1000 seed mass and head grain content.

Table 2 Vegetation period, plant stand density and crop yield of rice Syr Suluyi treated with “Fitop 8.67” 2020.

#	Sort	Experiment variant	Vegetation period, days	Plant stand density, pc/m^2	Crop yield	
					Hundred kg/ha	%
1	Syr Suluyi	No treatment	110	59	57.5	100
2	Syr Suluyi	Treated	108	65	62.2	108

Table 3 Effect of “NacLee” preparation on the crop yield structure for rice Syr Suluyi, 2020.

#	Sort	Experiment variant	Plant height, cm	Tilling capacity, pc.	Main head			Total number of grain, pc.	Crop yield, hundred kg/ha
					quantity, pc	length,cm	mass,g		
1	Syr Suluyi	No treatment	141.8	3.0	3.0	13.0	8.96	365.2	37.0
2	Syr Suluyi	Treated	143.0	6.2	6.0	15.8	11.5	392	40.0

According to the biometric analysis data, the control group productive tilling capacity was 2.9, main head length – 18.7; number of grain in the main head – 89.7 pc., and grain weight – 2.9; number of grain from one plant – 117.5 pc. The NacLee variant showed productive tilling capacity 3.3; main head length – 19.9; number of main head grain – 104.6, grain weight – 3.4; and the number of grain from one plant – 167.6 pc. The Fitop 8.67 variant showed productive tilling capacity 3.3; main head length – 21.1; number of main head grain – 121.0, grain weight – 4.5; and number of grain from one plant – 177.3 pc.

Thus, the results of the field experiments with biological liquid micronutrient fertilizer NacLee and Fitop 8.67 preparation on rice demonstrated that the most effective methods of micronutrient fertilizer application are pre-sowing seed treatment and top dressing during tillering and ear emergency. The reason for this is that these micronutrient fertilizers and the preparation stimulate growth of powerful root system and top of rice plants. Eventually, this provides a significant yield gain.

Conclusion

The multiannual field and production experiments on testing these micronutrient fertilizers on grain cultures, potatoes, vegetable, fruit, berry, and flower cultures, held by scientists and manufacturers in different natural areas of Kazakhstan and abroad (Italy, Spain, China, Russia, Turkey, Vietnam) demonstrated the effects of stimulating the length and biomass of the root system to 15-20%, total biomass of plants to 20-25% and more, increase of crop yield to 20-30%.

Biological preparations and micronutrient fertilizers for plant protection are an environmentally safe alternative to chemical (synthetic) pesticides. The results of the field experiments with biological liquid micronutrient fertilizer NacLee and Fitop 8.67 preparation on rice demonstrated that the most effective methods of micronutrient fertilizer application are pre-sowing seed treatment and top dressing during tillering and ear emergency. The reason for this

is that these micronutrient fertilizers and the preparation stimulate growth of powerful root system and top of rice plants.

When treating rice in tillering phase with MicroCat Cereal Start and Kelik K + Si in stem elongation phase, the leaf area of one plant increased twice compared to the control group. This provided increase of crop yield mainly through minimization of blind-seed disease and increase of grain mass obtained from a plant.

Declarations

Not applicable

Ethical Approval and Consent to participate

- Consent for publication
- Availability of supporting data
- Competing interests
- Funding
- Authors' contributions
- Acknowledgements
- Authors' information

Not applicable

Data repository

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