Improving the elements of organic farming in rice cultivation

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Abstract. The guarantee of food security of any state is to obtain guaranteed yields of high-quality agricultural products. The implementation of such a task is feasible only if all the technological and environmental conditions of its cultivation are met. In the current situation, when, along with the growing anthropogenic load on the land of the agricultural Fund and the reduction of available irrigation water, as well as non-compliance with agricultural production technologies, organic farming is the solution to the urgent problem of obtaining high yields of high-quality products without compromising the agricultural resource potential of soils. The transfer of production to organic farming should be carried out in stages, due to the high cost of its implementation and the use of a large number of additional resources (agro-reclamation, economic, energy, labor, technical and technological, environmental). In our research, we suggest using an organic method for cleaning drainage runoff with halophytes planted in phytosections located in the discharge channels of the rice irrigation system. It was found that the use of phytosections of various lengths, depending on the chemical composition of drainage and discharge waters, allows one to clean the drainage runoff from mechanical impurities, organic and biogenic elements. This makes it possible to reduce suffusion and removal of nutrients from rice checks, reduce the irrigation rate by 10%, increase the reclamation state of soils, and reduce the cost of rice production by 7%.

1. Introduction
Rice is a crop of strategic importance for any state. In a modern technocratic society with a constantly growing level of scientific and technological progress, it is necessary to improve annually the applied rice cultivation technologies in order to preserve the agricultural resource potential of the soil and obtain guaranteed high and environmentally friendly rice yields [1]. However, in fact, many technological operations are not improved, but not fully implemented due to the lack of economic and/or technical capabilities of farms. As a rule, the reduction of agrarian resources soil capacity is compensated by means of introduction of additional doses of fertilizers, which reduces the quality of grain, worsens ameliorative soil condition and leads to severe pollution of drainage outflow [2].

World research in the field of improving methods of growing crops proves that the solution to the problem of maintaining a favorable ecological and ameliorative situation in the rice irrigation system and obtaining guaranteed high yields of high-quality grains is to shift to organic farming [3]. Unfortunately, in the Russian Federation, unlike other leading agricultural countries of the world, there are no standards defining the criteria of organic production of agricultural products, and due to speculation in the market of "environmentally friendly" products, since January 1, 2004, it is generally forbidden to label them in this way [4].
2. Relevance, scientific significance
Currently, in Russia, in particular in Kuban, many farmers in the rice industry would like to transfer to the production and sale of biologically pure and high-quality products through a network of branded stores [5,6]. They are constrained by the lack of a regulatory framework, lack of knowledge about the mechanisms and technologies of such a transition, while in the practice of rice growing in Kuban there are precedents for the transition to environmentally friendly technologies of individual farms [7]. The importance of using such technologies is difficult to overestimate, and the accumulation of positive experience in the use of organic technologies will not only bring the agro-industrial complex of Russia to a completely new level of farming, but also creates prerequisites for the improvement of the nation [8,9].

3. Statement of the problem
The main objective of increasing the profitability of rice production is to reduce the cost of its production [10]. To date, the largest expenditures are spent on annual maintenance work on the rice irrigation system (maintenance of water supply, drainage, discharge and fencing networks, hydraulic structures, automation devices, communications, road networks and forest belts), performing a complex of agrotechnological operations, and paying for water supply and drainage services on the rice irrigation system [11,12].

Studies show that rice, with the adopted technology of flooding cultivation, consumes half of the total volume of irrigation water or up to 30% of all fresh water reserves in the world. At the same time, the biological demand of rice itself is much lower (6-8 thousand m$^3$ of water, depending on weather and soil conditions), the rest is spent on lateral outflow, filtration and discharge [13]. It is especially important to note the filtration losses, which according to various estimates range from 25% to 50% of the total volume of water supplied to the irrigation system (for heavy soils) and 50% -85% – for soils with a light granulometric composition. All the filtration runoff and waste water intercepted by the drainage and discharge network of channels carry out not only organic substances from rice fields, but also pesticides and herbicides introduced in the rice production process. Therefore, one of the main tasks of increasing the profitability of rice is to reduce the irrigation rate by reducing the filtration outflow from rice checks, reducing the application of mineral fertilizers [14]. Up to the complete rejection of them and the transition to the herbicide-free technology of rice cultivation, increasing the efficiency of drainage runoff purification from organic substances, biogenic elements and mechanical impurities.

4. Theoretical part
In our studies, we propose the method of cleaning drainage flow of rice irrigation system, which is as follows: in the first year of implementation of the method of cleaning drainage flow of rice irrigation systems, phyto-sections are formed in different waste channels according to the following scheme: $a-b-a$ (Figure 1).

![Figure 1](https://example.com/figure1.png)

Figure 1. Scheme of discharge channel with placed phyto-section in it: where $a$ – distance along the length of the discharge channel, in meters, with the planting of halophyte of Tator; $b$ – distance along the length of the discharge channel, in meters, with the planting of the halophyte Eichhornia; $l$ – length of the phyto-section; 1 – discharge channel.
Planting the perennial halophyte of Tator is carried out once in autumn, in the first year of implementation of the method of cleaning drainage flow of rice irrigation systems after the shutoff of water for rice irrigation system for the entire width of the discharge channel, including the slopes. And planting of the halophyte Eichhornia is performed annually in the spring after the water supply for rice irrigation system directly to the water surface of drainage and waste flow in the waste channel.

Every autumn, before blackout of the water supply to rice irrigation system, the halophytes of Tator and Eichhornia are mowed and introduced into rice fields. And after blackout of water supply to rice irrigation system, the halophytes of Tator and Eichhornia are mowed and introduced into rice fields to enrich the soil organic matter after grinding to improve reclamation condition of the soil, and then annual planned repair and maintenance works are made in the rice irrigation system.

In order to establish economic-ecological optimum, the distance for the values of a and b in phyto-sections is taken in different variants of the length of planting along the length of the discharge channel. Then immediately after passing the drain-waste channel of the phyto-section, sampling was performed and their chemical composition was determined, and then compared with the results of the chemical composition of samples from the discharge channel without phyto-sections (control) including a conclusion about the most effective phyto-section.

5. Practical significance, proposals and results of implementation

Tests of the method of cleaning the drainage runoff of the rice irrigation system were carried out in Krasnodar Territory in the JSC “Chernoerkovskoye” of Slavyansky district (2nd division). All fields of the farm use maps of the Krasnodar type, and the cultivated rice crop is the variety Limanny. Irrigation mode is constant flooding. The fertilizer dose is N_{120}P_{40}K_{60}.

In order to establish the economic-ecological-optimal distance for the values of a and b in the phyto-section, three groups of schemes were adopted with the following options: 1 group: 10-50-10, 10-100-10, 10-150-10; 2 group: 20-50-20, 20-100-20, 20-150-20; 3 group: 30-50-30, 30-100-30, 30-150-30.

To determine the efficiency of phyto-sections during the growing season of rice, at the beginning, middle and end of the growing season, samples of drainage and discharge runoff were taken and its chemical composition was determined. At the same time, sampling of drainage and discharge runoff was performed immediately after passing the phyto-section.

### Table 1. Chemical content of drainage waters in the first group of schemes of phyto-sections.

| Schemes of phyto-sections | 10-50-10 | 10-100-10 | 10-150-10 |
|---------------------------|---------|-----------|------------|
| Date of selection         | 05.08.2018 | 02.09.2018 | 05.08.2018 |
| Water chemical content    | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l |
| HCO₃, hydrocarbonate      | - | - | - | - | - | - | - | - | - | - | - |
| CO₃, carbonate            | - | - | - | - | - | - | - | - | - | - | - |
| Cl, chlorine              | - | - | - | - | - | - | - | - | - | - | - |
| SO₄, sulphate             | - | - | - | - | - | - | - | - | - | - | - |
| NO₃, nitrate              | - | - | - | - | - | - | - | - | - | - | - |
| NO₂, nitrite              | - | - | - | - | - | - | - | - | - | - | - |
| Sum of cations            | - | - | - | - | - | - | - | - | - | - | - |
| Ca, Calcium               | 762 12 50 691 11.33 652 10.69 748 12.27 675 11.07 634 10.40 735 12.05 658 10.79 615 10.09 |
| Mg, Magnesium             | 414 11 67 387 10.91 351 9.90 401 11.31 356 10.04 312 8.80 381 10.74 352 9.92 310 8.74 |
| Na, Sodium                | 1594 32.22 1404 29.26 1352 28.18 1489 31.03 1368 28.51 1321 27.53 1449 30.20 1341 27.95 1288 26.84 |
| K, Potassium              | 621 31.05 594 29.70 570 28.50 551 27.55 518 25.90 499 24.95 478 23.90 452 22.60 427 21.35 |
| Sum of cations            | 57.39 | 51.50 | 48.76 | 54.60 | 49.61 | 46.72 | 52.99 | 48.66 | 45.67 | - | - |
| pH                        | 7.7 | 7.7 | 7.7 | 7.6 | 7.6 | 7.5 | 7.5 | 7.4 | 7.4 | 7.4 | 7.4 |
| CO₂ free carbonic acid    | 40 | 0.88 | 39 | 0.86 | 36.0 | 0.79 | 35 | 0.77 | 33 | 0.73 | 30.0 | 0.41 | 36.8 | 28.06 | 27.59 | 25.05 | 25.05 |
| Dry rest                  | 3661 | 3363 | 3202 | 3397 | 3143 | 2993 | 3201 | 2975 | 2811 | - | - |
| Sum of ions               | 4042 | 3708 | 3528 | 3771 | 3480 | 3310 | 3568 | 3304 | 3118 | - | - |
It was found that the greatest pollution of drainage and discharge runoff was observed during the end of tillering and before the phase of full maturing - the beginning of waxy ripeness of rice. This happens when a water layer of 10-12 centimeters is created and maintained on the checks, and the maximum filtration of irrigation water from the check to the drainage network of the rice irrigation system occurs.

From tables 1-4, it was found that the most effective schemes of group 2 and the most effective version of the phyto-section in the second group according to the scheme a-b-a are 20-150-20.

### Table 2. Chemical content of drainage waters in the second group of schemes of phyto-sections.

| Date of selection | 05.08. | 02.09 | 25.06. | 05.08. | 02.09. | 25.06. | 05.08. | 02.09. | 25.06. |
|-------------------|--------|-------|--------|--------|--------|--------|--------|--------|--------|
| 20-50-20          | mg/l   | mg/l  | mg/l   | mg/l   | mg/l   | mg/l   | mg/l   | mg/l   | mg/l   |
| 2018              |        |       |        |        |        |        |        |        |        |
| HCO₃⁻/hydrocarbonate | 714   | 11.71 | 624    | 10.23  | 581    | 9.53   | 567    | 9.43   | 564    |
| CO₃⁻/carbonate    | 535    | 4.95  | 319    | 8.99   | 297    | 7.87   | 327    | 9.22   | 280    |
| Cl⁻/chloride      | 1412   | 29.43 | 1290   | 26.88  | 1229   | 25.61  | 1375   | 28.65  | 1246   |
| SO₄²⁻/sulphate    | 1194   | 24.88 | 1327   | 27.65  | 1204   | 25.09  | 1152   | 24.01  |        |
| NO₃⁻/nitrate      | 651    | 9.08  | 549    | 9.00   | 513    | 8.41   |        |        |        |
| NO₂⁻/nitrite      |        |       |        |        |        |        |        |        |        |
| Sum of anions     | - 51.09| 46.11 | - 43.01| 49.06  | - 43.47| 41.07  | - 46.73| 41.11  | - 38.40|
| Ca²⁺ Calcium      | 398    | 19.90 | 379    | 18.95  | 355    | 17.75  | 326    | 16.30  | 298    |
| Mg²⁺ Magnesium    | 89     | 7.43  | 82     | 6.84   | 75     | 6.26   | 69     | 5.76   | 58     |
| Na⁺ Sodium        | 349    | 15.17 | 332    | 14.43  | 312    | 13.57  | 295    | 12.83  | 271    |
| K⁺ Potassium      | 12     | 0.31  | 12     | 0.31   | 11     | 0.29   | 11     | 0.29   | 10     |
| Sum of cations    | - 42.81| 40.54 | - 37.86| 35.17  | - 31.78| 29.29  | - 26.60| 23.80  |        |
| pH                | 7.4     | 7.2   | 7.3    | 7.1    | 7.1    | 7.0    |        |        |        |
| CO₂ free carbonic acid oxidation | 23 | 0.51  | 20.44 | 17  | 0.37 | 15  | 0.33  | 13  | 0.29  |
| dry rest          | 2970   | 2726  | 2552   | 2744   | 2456   | 2311   | 2486   | 2201   | 2084.5 |
| sum of ions       | 3327   | 3038  | 2842   | 3085   | 2749   | 2593   | 2811   | 2476   | 2305   |

### 6. Conclusions

The studies proved that the creation of a backwater precinct in the channel due to the passage of drainage discharge runoff through phyto-section reduces the filtration of the outflow of irrigation water from rice check. It also reduces the loss of irrigation water, reduces the suffusion and the removal of nutrients from the arable layer. That together with the application of halophytes in rice fields leads to soil improvement and ecological situation in the rice irrigation system (Table 5).
assess changes in the reclamation state of the soil, soil samples were taken from the rice checks of three rice fields with plot channels belonging to the second group of phyto-section schemes.

### Table 4. Chemical content of drainage waters – control

| Schemes of phyto-sections | Date of selection | Units of measurements | mg/l | mg-eq | mg/l | mg-eq | mg/l | mg-eq |
|---------------------------|-------------------|-----------------------|------|-------|------|-------|------|-------|
|                           | 05.08.2018        |                       |      |       |      |       |      |       |
|                           | 02.09.2018        |                       |      |       |      |       |      |       |
|                           | 25.06.2018        |                       |      |       |      |       |      |       |
| **anions**                |                   |                       |      |       |      |       |      |       |
| HCO₃, hydrocarbonate      | 890               | 14.59                 | 826  | 13.55 | 794  | 13.02 |      |       |
| CO₃, carbonate            |                   |                       |      |       |      |       |      |       |
| Cl, chlorine              | 452               | 12.74                 | 422  | 11.90 | 398  | 11.22 |      |       |
| SO₄, sulphate             | 1793              | 37.37                 | 1685 | 35.12 | 1591 | 33.16 |      |       |
| NO₃,nitrate               |                   |                       |      |       |      |       |      |       |
| NO₂,nitrite              |                   |                       |      |       |      |       |      |       |
| Sum of anions             | -                 | 64.70                 | -    | 60.56 | -    | 57.40 |      |       |
| Ca²⁺ Calcium             | 644               | 32.20                 | 631  | 31.55 | 609  | 30.45 |      |       |
| Mg²⁺ Magnesium           | 158               | 13.19                 | 152  | 12.69 | 144  | 12.02 |      |       |
| Na⁺ Sodium               | 506               | 22.00                 | 491  | 21.35 | 478  | 20.78 |      |       |
| K⁺ Potassium             | 19                | 0.49                  | 18   | 0.47  | 17   | 0.44  |      |       |
| Sum of cations           | -                 | 67.88                 | -    | 66.05 | -    | 63.69 |      |       |
| pH                       |                   | 7.8                   | 7.8  | 7.8   | 7.8  | 7.8   |      |       |
| CO₂, free carbonic acid  | 42                | 0.92                  | 41   | 0.90  | 39   | 0.86  |      |       |
| oxidation                |                   |                       |      |       |      |       |      |       |
| dry rest                 | 2975              | 2810.5                |      |       |      |       |      |       |
| sum of ions              | 3304              | 3118                  |      |       |      |       |      |       |

### Table 5. Change of ameliorative soil condition of rice checks

| Title           | Depth of sample, cm | Content of aggregates 0,25-10mm, % from the mass of air-dry soil | Sum of waterproof aggregates >0,25mm, % | Hydrolyzed nitrogen, mg/100 g | Phosphorus fluid, mg/100 g | Potassium fluid, mg/100 g | % humus on absolutely dry soil |
|-----------------|---------------------|---------------------------------------------------------------|----------------------------------------|-------------------------------|---------------------------|--------------------------|-------------------------------|
| Phyto-section   |                     |                                                               |                                        |                               |                           |                          |                               |
| 20-50-20        | 0-5                 | 47.9                                                          | 30.2                                   | 3.82                          | 2.21                      | 7.7                      | 3.28                          |
|                 | 5-10                | 43.2                                                          | 28.4                                   | 3.12                          | 1.96                      | 7.5                      | 2.99                          |
| Phyto-section   |                     |                                                               |                                        |                               |                           |                          |                               |
| 20-100-20       | 0-5                 | 48.3                                                          | 31.6                                   | 3.94                          | 2.33                      | 7.7                      | 3.30                          |
|                 | 5-10                | 43.4                                                          | 29.3                                   | 3.26                          | 2.23                      | 7.6                      | 3.02                          |
| Phyto-section   |                     |                                                               |                                        |                               |                           |                          |                               |
| 20-150-20       | 0-5                 | 49.5                                                          | 32.8                                   | 4.12                          | 2.56                      | 7.8                      | 3.32                          |
|                 | 5-10                | 43.6                                                          | 30.6                                   | 3.89                          | 2.32                      | 7.6                      | 3.05                          |
| control         | 0-5                 | 38.8                                                          | 29.2                                   | 3.57                          | 2.05                      | 7.5                      | 3.25                          |
|                 | 5-10                | 30.9                                                          | 27.4                                   | 3.03                          | 1.84                      | 7.2                      | 2.98                          |

Analysis of the data in Table 5 showed an improvement in the reclamation state of rice field soils and confirmed the effectiveness in comparison with the control of the proposed method of cleaning the drainage runoff of the rice irrigation system (Table 5).

By reducing irrigation water losses by reducing the filtration outflow of irrigation water, and, consequently, reducing the suffusion and removal of nutrients from the arable horizon from the rice check, it was possible to reduce the irrigation rate by 10%, decrease the dose of organic and mineral fertilizers by 15%, and diminish the cost of rice production by 7%.

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