HANDLING, TRANSPORTING, STORAGE AND PROTECTION OF AGRICULTURAL PRODUCTS

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JUSTIFICATION OF RICE WATERING METHODS AND CROP CULTURES

Research article

Abstract

The article discusses the need for the use of resource-saving and environmental protection systems of agriculture in the rice growing of the Krasnodar Territory. Due to the fact that rice irrigation systems located in the Krasnodar Territory are outdated, and projects aimed at the reconstruction of these systems do not always meet ecological-landscape principles, the efficiency of their use has decreased, which leads to environmental and economic problems such as as salinization, reduction of soil fertility and reduction of agro-resource potential of land. To eliminate these problems arising in such conditions, certain costs are necessary, which reduces the profitability of rice cultivation and can lead to the ruin of farms. To avoid these problems, a number of activities are being carried out, which consider possible solutions to these problems, aimed at expanding the functional capabilities of rice irrigation systems through reconstruction projects that will yield high yields and increase the efficiency of using natural resources, such as water and land.

Keywords: rice, mode, watering, crop rotation, field, soil, bias, relief, sowing.

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ОБОСНОВАНИЕ СПОСОБОВ ПОЛИВА РИСА И СЕВООБОРОТНЫХ КУЛЬТУР

Научная статья

Аннотация

В статье рассматривается необходимость использования ресурсосберегающих и природоохранных систем земледелия в рисоводстве Краснодарского края. Из-за того, что рисовые оросительные системы, находящиеся в Краснодарском крае, устарели, а проекты, направленные на реконструкцию этих систем, не всегда отвечают эколого-ландшафтным принципам, снизилась эффективность их использования, что и приводит к возникновению экологических и экономических проблем, таких как засоление, снижение плодородия почв и уменьшения агроресурсного потенциала земель. На устранение этих проблем, возникающих в таких условиях, необходимы определенные затраты, что снижает рентабельность возделывания риса и может привести к разорению хозяйств. Чтобы не возникало этих проблем, проводится ряд мероприятий, в которых рассматриваются возможные решения этих проблем, направленные на расширение функциональных возможностей рисовых оросительных систем, за счет проектов по реконструкции которые будут давать высокую урожайность и увеличение эффективности использования природных ресурсов, таких как водных и земельных.

Ключевые слова: рис, режим, полив, севооборот, поле, почва, уклон, рельеф, посев.

1. Introduction

Most of rice irrigation systems in the Krasnodar Krai have exhausted their former potential and are outdated, partially or completely, and has to be reconstructed, and this is the goal of our research, to address the constraining factor of irrigated systems in the Kuban. For example, the efficiency of rice irrigation systems in farms on the left bank of the Kuban fell to 0.48–0.72, in the Crimean and Abinsk districts it was 0.66 and 0.62, respectively, and for the rice irrigation system of the Krasnodar Krai this index is 0.76, which is significantly below the norm [1, 2].

In order to increase the efficiency of land and water resources usage, it is necessary to reorganize rice irrigation systems, which will allow creating optimal water availability during the operation of irrigation systems. This creates the necessary conditions and significantly increase the rate of the pace of sowing and harvesting, besides a favorable salt, water-air, and thermal regime will be maintained in soil throughout the year and the non-growing season [3, 4, 5].

Reconstruction of the rice irrigation system should be ensured by a sufficient yield of rice and associated crops. Due to this, integrated and rational use of land resources is necessary for accordance with the main provisions of a sustainable rice-growing strategy on an ecological-landscape basis [6].

Rice crop rotations at range expanding, which, in addition to rice, include grain, spring, tilled, and winter crops, will ensure an increase in rice productivity.

The use of a particular irrigation method in the rice cultivation without a water layer depends primarily on terrain, soil conditions and agricultural technology [7, 8]. Terrain can be roughly estimated as flat (non-sloping with a pronounced micro-relief), flat with an average (from 0.002 to 0.01) and with a significant (more than 0.01) slope and complex, with longitudinal and transverse slopes. On a landless terrain, subsurface irrigation or sprinkling should be developed in priority. On a plain with small slopes, superficial methods of furrow irrigation, a start-up by lanes, subsurface irrigation, sprinkling with low rain intensity are acceptable. On the plains with significant slopes – they use mainly sprinkling with low rain intensity, and pulsed, furrow irrigation and subsurface irrigation are also applied. Only sprinkling is possible on complex terrain without careful planning. The second indicator of the applicability of a particular irrigation method is soil characterization. According to the mechanical composition, and, consequently, according to the intensity of water absorption, the soils are divided into light, medium and heavy ones. Under flat terrain on heavy soils with well-defined capillarity, subsurface irrigation on soils with an average absorption rate is recommended, sprinkling and subsurface irrigation are preferable. Only sprinkling is possible on light soils under these conditions. Sprinkling with very low rain intensity is applicable on plains with significant slopes on heavy soils, watering through deep furrows slots is used on medium and light soils, and sub-irrigation – on heavy soils. The third indicator – agricultural technology is of great importance when choosing an irrigation method and technique, regardless of the listed conditions. In each case, the irrigation method of rice cultivated without a water layer should be chosen so that the normal conditions of aeration of a soil to be preserved, without them, plants cannot form a root system of upland type.

From this point of view, the best method of watering is the subsoil, followed by watering along furrows and flowing furrows, and finally flooding along the lanes. The last place is irrigated by sprinkling. Thus, when cultivating low-requiring rice varieties without a water layer, the irrigation methods that do not compact the soil, do not create a crust on its surface, do not impair aeration conditions, and retain the structure are preferable. It is watered along furrows-slots, along usual flowing grooves and subsurface irrigation. On soils with a good water-resistant structure, when sowing rice in a layer of perennial grasses, irrigation along the lanes with head water, but a small specific stream is also applicable. However, here in the first phases of rice growth, it may be necessary after irrigation to harrow as a means of enhancing soil aeration. As for the heating of checks, it should be completely excluded.

Of the surface irrigation methods, watering along flowing furrows is the most promising for growing rice with periodic irrigation [9, 10]. The distance between the furrows and their length depends on the water-physical properties of the soil and the slope of terrain. On moderate soils with good lateral filtration, the distance between the furrows of 100-120 cm can be taken, the length of the furrows is 150-300 m, on the medium-light, and 75-100 cm and 100-150 m, on light ones - 45-75 cm and 60-80 m respectively. Water consumption in the furrow, depending on soil conditions and the slope is set from 0.25 to 0.75 l/s. Furrows are cut at the same time as sowing. At the same time, the bottom of the furrow is left unplanted so that that water can move freely during irrigation. With the method of irrigation under consideration, the inter-abdominal spaces, moistened by infiltration, remain loose, and the crust does not form on them, only the bottom of the furrow is compacted, favorable conditions are created where there is no rice: shoots are obtained with one thing – irrigation without harrowing the plants. Irrigation in flowing furrows approaches in efficiency to sub-soil irrigation [11].

The farms of the Krasnodar Krai have already introduced new-generation landscape-reclamation systems, which include the main principles of the strategy of sustainable development of rice growing [12, 13, 14].

2. Methods

The methods presented in the article for applying various irrigation methods depending on the relief and soil methods are confirmed by long-term experimental data [15, 16].

Knowledge of the patterns of daily water consumption changing for periodically irrigated rice by periods of its growth makes it possible to rationally distribute the irrigation time (Figure 1).

The first watering is carried out before sowing rice (presowing irrigation). With sufficient reserves of moisture in the soil from the autumn - winter-spring period, it is possible to get rice seedlings without pre-sowing irrigation, and vegetative irrigations are given depending on the average daily water consumption of rice. In the first period of its growth – from germination to tillering - about 15 m^3/day is consumed for evaporation from the soil surface and transpiration. This period averaged 35 days - from May 15 (emergence) until June 20 (rice tillering). Moisture reserves, created as a result of watering for the emergence of shoots, last for 25-30 days. The next watering, therefore, is carried out at the beginning of tillering, about June 15-18. In the period from tillering to going into the pipe, water consumption reaches 42 m^3/day×ha. This period lasts about 25 days, and to satisfy the rice plants with water, it is necessary to give two irrigations of 500-600 m^3/ha. The rice plants release period in the tube is characterized by an average daily water consumption of about 72 m^3/ha; It lasts 21-22 days, as a rule, from mid-July to the first decade of August. At this time, usually there is no precipitation, the temperature is the highest in the year, so for this period they give three irrigations in 5-7 days. Irrigation norms are the same - 500-600 m^3/ha. The extremely critical period is the sweeping panicle phase [17, 18]. It lasts 5-7 days and falls in the middle of August, at this time the highest daily water consumption is observed - about 100 m^3/ha and more. With sufficient provision in previous periods, the panicle-sweeping phase requires 1 or 2 waterings. In the phase of filling and milky ripeness, the daily run of water is reduced to 68 m^3/ha, and two irrigations are enough to supply such a flow rate. At the last stage – the completion of wax and full ripeness - the daily consumption is about 23 m^3/ha, and irrigation at this time can be omitted.

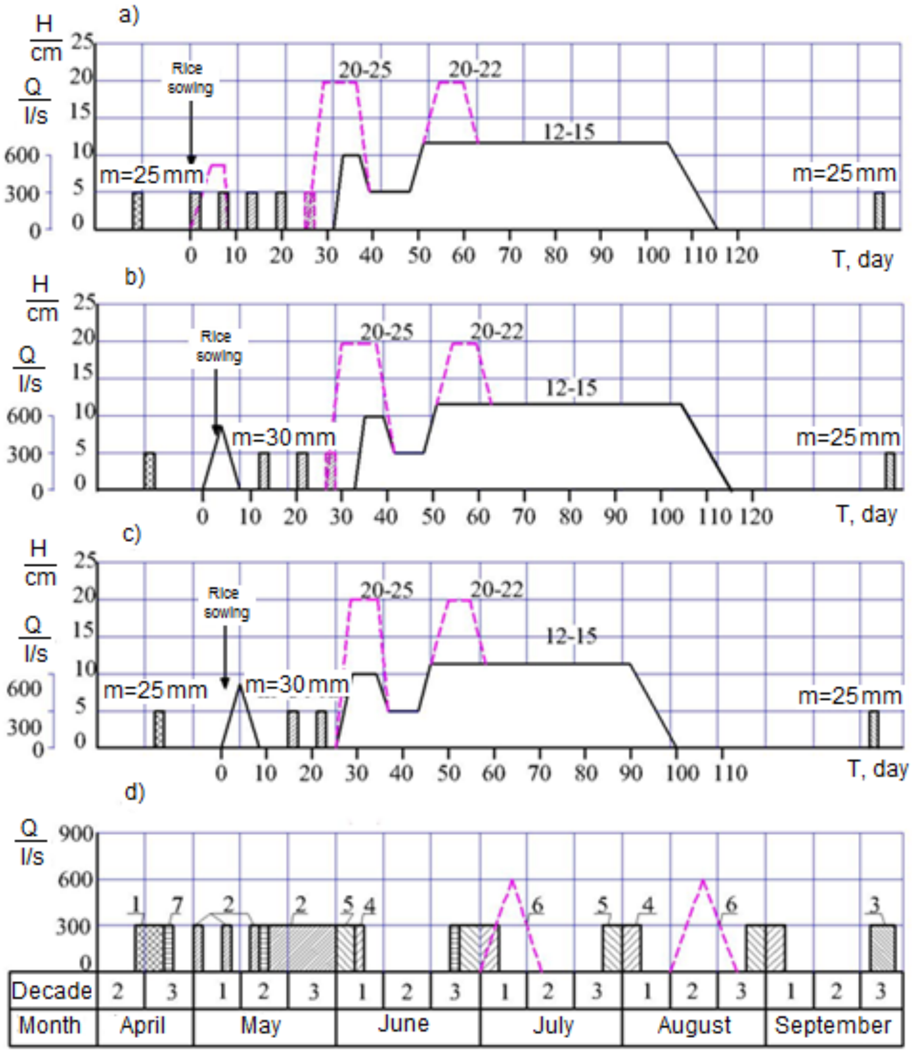

Figure 1. Irrigation regime and irrigation technology of rice and alfalfa in rice crop rotations

This distribution of irrigation with an almost rainless summer ensures the maintenance of soil moisture at a level not lower than 80% of field capacity. With precipitation, inter-irrigation periods increase and decrease the number of irrigations. If rain brought no more than 10 mm per day, then we should not give up watering [19, 20]. When precipitation is over 20 mm per day, watering can be postponed for 2-3 days, and with precipitation of 30 mm per day and above that, watering can be avoided. However, it should be noted that the necessary soil moisture regime can be maintained only by systematically sampling the soil and determining its moisture. This applies not only to periodic rice crops but to irrigated crops in general.

With surface irrigation along flowing grooves and lanes with proper preparation of the soil surface and application of irrigation fittings (irrigation pipes, siphons, portable shields), one person can handle up to 30 hectares of irrigated area with nine irrigations during the growing season [21]. The flow through the furrows or strips of rice can also be watered with a variable jet from a single-breasted furrow [22].

When irrigating with a variable jet, the maximum flow rate is first fed into the furrow, which is safe from the point of view of soil erosion, and then, when the water reaches the end of the furrows, the flow rate is approximately halved, removing part of the siphons and transferring them to other furrows [23].

Such a situation is indisputable; it has been tested under production conditions and makes it necessary to raise the question of creating special control and technological laboratories on irrigated farms. Without this, it is difficult to guarantee the yield of such crops, which can give irrigated land. The described irrigation regime provides for soil moistening by 50-60 cm, where the bulk of the active rice roots are located. Irrigation rates of 500-700 m^3/ha are required to moisten this layer. However, the root system of poorly demanding rice varieties on light, well-aerated soils reaches a depth of 1 m. Therefore, by creating moisture reserves available to rice plants in a meter-thick layer of soil, we provide plants with water for a longer period, and due to this, we can slightly increase the duration of inter-irrigation periods, accordingly reducing the number of waterings. To create a reserve of moisture in the meter layer, the rate of 1-2 irrigations should be increased to 900-1000 m^3/ha. When irrigating with sprinkling, it is difficult to irrigate at 500-600 m^3/ha rate (Figure 1).

At the unplanned surface or when planning it under an inclined plane, large losses of water to the drain occur [24]. In this case, the absorption and wetting of the soil are insufficient. Therefore, when irrigating rice with sprinkling, it is necessary to give more frequent irrigations, reducing the irrigation rate to 250-300 m^3/ha. The number of irrigations during sprinkling increases by 2-3 and reaches 8-12 at an irrigation rate of 3.5-5.0 thousand m^3/ha.

At sprinkling, the root system is not as deep as with surface irrigation. Therefore, yields never reach the same values during sprinkling as with surface irrigation along furrows or stripes [24, 25]. Also, irrigation by sprinkling hurts the structure of the surface layers of the soil, which is undesirable when growing rice with periodic irrigation [12, 26]. Normal provision of rice plants with water with high agronomic cultivation provides high yields [2, 27], and under such conditions, water consumption per ton of grain yield is the lowest.

As part of the research named: "Development of a balanced rice irrigation system for managing the reclamation state of the soil in existing and restored rice fields" we suggest to allocate a rice system within the boundaries of the ameliorative water intake as a single structural element for developing an optimal set of technological operations and managing the reclamation state of the soil, increase rice yields and energy savings in existing and restored rice fields [1, 23].

The monitoring of soil indicators in the Kalininsky district allowed to assess the ameliorative state of the soils of the rice irrigation system (Figure 2).

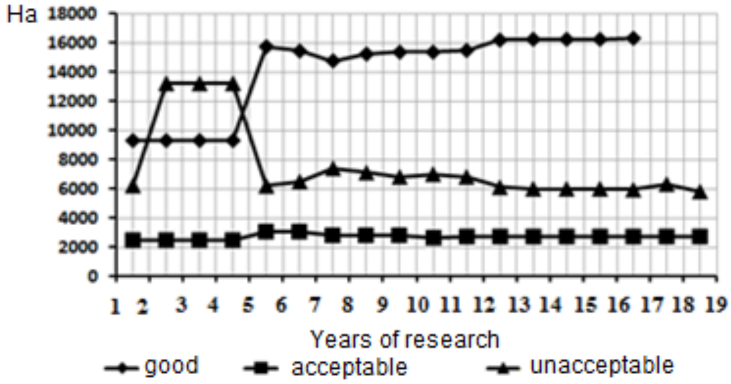

Figure 2. Change of ameliorative condition of soils in Kalininsky district

The analysis of the increase in area by 35% from the unsatisfactory soil ameliorative condition for the period from 1 to 5 years of research in the Kalininsky district showed that this was caused by the deterioration of pumping stations, as a result of which the land area flooded by groundwater increased by 3 times (Figure 3), which in turn, caused an increase in soil areas with an unacceptable degree of salinity by 45% [21].

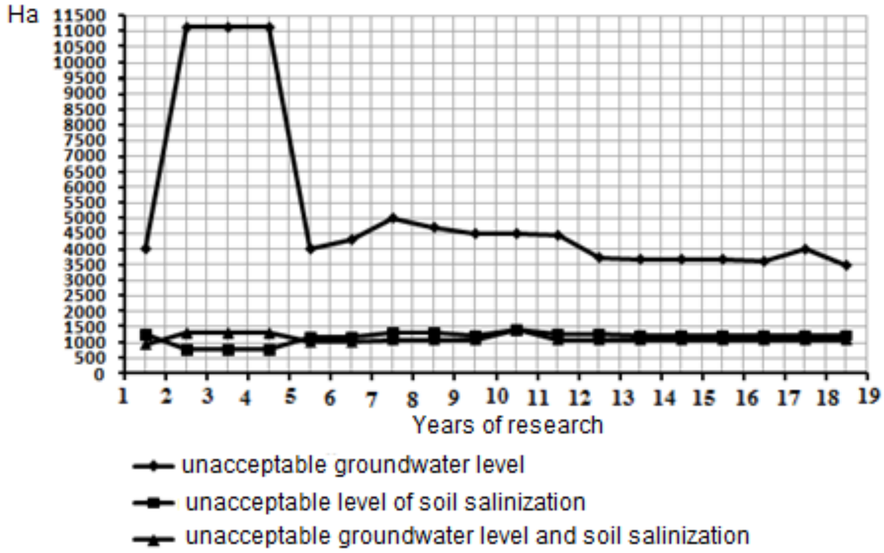

Figure 3. Change of areas with an unacceptable level and degree of mineralization

A study of the ameliorative state of the soil in Krasnoarmeysky and Kalininsky districts of the Krasnodar Krai showed that all farms have problems associated with a decrease in the ameliorative state of the soil and the lack of energy and labor resources. So, the share of farms where it is required the technological level of land-reclamation systems in the Kalininsky district is 20%, and 9% require reclamation improvement, and the technical condition of the whole collector-drainage network is assessed as satisfactory with further deterioration.

The effectiveness of crop rotation is determined by the number of products obtained and the amount of the costs of their production. The existing methods of calculation take into account the cost of production (for technological cards) and the cost of the resulting products.

Based on the cost of production and the price of its realization, the competitiveness of products and the profit of the agricultural producer are determined [10, 12].

At the same time, the cultivation of crops in crop rotation does not take into account the indirect effect obtained from increasing soil fertility, for example, from perennial grasses, in particular, alfalfa, which can be cultivated in the soil, according to M.I. Tarkovsky (1964) to 150-200 kg/nitrogen. Alfalfa enhances the biological activity, improves the physical and chemical properties of the soil, helps to increase the yield of subsequent crops.

Lucerne, according to N.G. Malyugi, after two years of cultivation, leaves one ton of nitrate, which makes it possible to reduce the cost of mineral nutrition of crops [15].

The ability of alfalfa to improve water-physical properties, reduce soil salinity, makes it an indispensable component of rice crop rotations [28].

By presenting the scheme of the eight-field crop rotation in the form of products in explicit – grain, hay, green fodder and not explicit – the amount of accumulated organic residues corresponding to a certain amount of organic or mineral fertilizers, one can evaluate the effectiveness of any crop rotation saturation (table 1).

Table 1. The scheme of the eight-field crop rotation with the resulting products

Field number	**Products received per unit area**							
Cultivation year	**1-st**	**2-nd**	**3-rd**	**4-th**	**5-th**	**6-th**	**7-th**	**8-th**
1-st	Green weight – 70-90 c/ha	Green weight – 250 kg/ha, hay – 65 kg/ha	Rice – 6.5 t/ha. Organ. mass eq. 30-40 t/manure	Rice – 6.0 t/ha. Organ. mass eq. 15-20 t/manure	Rice – 5.5 t/ha. Organ. mass eq. 0-5 t/manure	Destroying weed equiv. to reduc. of herbicides by 60-75%	Rice – 6.5 t/ha. Reduc. of herbicides by 20-25%	Rice – 6,0 t/ha, Reduc. of herbicides by 5-10%
2-nd	Green weight – 250 kg/ha, hay – 65 kg/ha	Rice – 6.5 t/ha. Organ. mass eq. 30-40 t/manure	Rice – 6.0 t/ha. Organ. mass eq. 15-20 t/manure	Rice – 5.5 t/ha. Organ. mass eq. 0-5 t/manure	Destroying weed equiv. to reduc. of herbicides by 60-75%	Rice – 6.5 t/ha. Reduc. of herbicides by 20-25%	Rice – 6,0 t/ha, Reduc. of herbicides by 5-10%	Green weight – 70-90 c/ha
3-rd	Rice – 6.5 t/ha. Organ. mass eq. 30-40 t/manure	Rice – 6.0 t/ha. Organ. mass eq. 15-20 t/manure	Rice – 5.5 t/ha. Organ. mass eq. 0-5 t/manure	Destroying weed equiv. to reduc. of herbicides by 60-75%	Rice – 6.5 t/ha. Reduc. of herbicides by 20-25%	Rice – 6,0 t/ha, Reduc. of herbicides by 5-10%	Green weight – 70-90 c/ha	Green weight – 250 kg/ha, hay – 65 kg/ha
4-th	Rice – 6.0 t/ha. Organ. mass eq. 15-20 t/manure	Rice – 5.5 t/ha. Organ. mass eq. 0-5 t/manure	Destroying weed equiv. to reduc. of herbicides by 60-75%	Rice – 6.5 t/ha. Reduc. of herbicides by 20-25%	Rice – 6,0 t/ha, Reduc. of herbicides by 5-10%	Green weight – 70-90 c/ha	Green weight – 250 kg/ha, hay – 65 kg/ha	Rice – 6.5 t/ha. Organ. mass eq. 30-40 t/manure
5- th	Rice – 5.5 t/ha. Organ. mass eq. 0-5 t/manure	Destroying weed equiv. to reduc. of herbicides by 60-75%	Rice – 6.5 t/ha. Reduc. of herbicides by 20-25%	Rice – 6,0 t/ha, Reduc. of herbicides by 5-10%	Green weight – 70-90 c/ha	Green weight – 250 kg/ha, hay – 65 kg/ha	Rice – 6.5 t/ha. Organ. mass eq. 30-40 t/manure	Rice – 6.0 t/ha. Organ. mass eq. 15-20 t/manure
6- th	Destroying weed equiv. to reduc. of herbicides by 60-75%	Rice – 6.5 t/ha. Reduc. of herbicides by 20-25%	Rice – 6,0 t/ha, Reduc. of herbicides by 5-10%	Green weight – 70-90 c/ha	Green weight – 250 kg/ha, hay – 65 kg/ha	Rice – 6.5 t/ha. Organ. mass eq. 30-40 t/manure	Rice – 6.0 t/ha. Organ. mass eq. 15-20 t/manure	Rice – 5.5 t/ha. Organ. mass eq. 0-5 t/manure
7- th	Rice – 6.5 t/ha. Reduc. of herbicides by 20-25%	Rice – 6,0 t/ha, Reduc. of herbicides by 5-10%	Green weight – 70-90 c/ha	Green weight – 250 kg/ha, hay – 65 kg/ha	Rice – 6.5 t/ha. Organ. mass eq. 30-40 t/manure	Rice – 6.0 t/ha. Organ. mass eq. 15-20 t/manure	Rice – 5.5 t/ha. Organ. mass eq. 0-5 t/manure	Destroying weed equiv. to reduc. of herbicides by 60-75%
8- th	Rice – 6,0 t/ha, Reduc. of herbicides by 5-10%	Green weight – 70-90 c/ha	Green weight – 250 kg/ha, hay – 65 kg/ha	Rice – 6.5 t/ha. Organ. mass eq.	Rice – 6.0 t/ha. Organ. mass eq.	Rice – 5.5 t/ha. Organ. mass eq. 0-5 t/manure	Destroying weed equiv. to reduc. of	Rice – 6.5 t/ha. Reduc. of herbicides by 20-25%

				30-40 t/manure	15-20 t/manure		herbicides by 60-75%	

According to table 1, employees of the agro-industrial complex can plan the profits from each field, as well as adjust fertilizer doses and carry out the necessary agrotechnical measures to develop and implement an innovatively-adaptive complex of technological operations and obtain guaranteed high yields of rice.

A system of measures is required for the reproduction of agricultural land fertility, land reclamation, and agrotechnical techniques, the application of organic and mineral fertilizers, etc. [29, 30]. But reclamation measures can have a negative impact on the environment and soil. To ensure the protection of water and land resources and the production of high-quality agricultural products, it is necessary to foresee and implement a set of measures.

The development of land reclamation measures, taking into account their costs, is a currently relevant task [31]. Justification of the choice of management decisions should be carried out, quantifying measures, their composition, volume, terms of entry, priority. Such calculations will allow to estimate in advance the consequences of the decision, eliminate unacceptable options and use cost-effective ones.

3. Conclusion.

In conclusion of the article, it can be noted that the problem of increasing the production of all types of grain and irrigating rice will remain one of the most important tasks of agriculture in our country for years. To solve them, one must use all the ways and opportunities. One of such opportunities is the expansion of rice crops in conventionally irrigated grain crop rotations, outside the boundaries of the zone typical for rice cultivation during flooding, where very high irrigation rates are required to maintain water. Only a reasonable application of both methods of rice cultivation will fully meet the needs of our country in such a valuable food product, as rice.

Studies have shown that the agro-resource potential of the rice irrigation system during the non-growing season is influenced by the following indicators, ranked by the degree of their influence: depth and salinity of groundwater; moisture, the mechanical and chemical composition of the soil.

According to the results of the years of research, relationships have been established between the main indicators of the soil parameters of the rice irrigation system during the non-growing season for managing the reclamation state: the groundwater level is determined by natural and climatic factors and on non-saline soils the depth of groundwater should not exceed 2.5 m for highly saline, 1.5 m for moderately saline and 0.5 m for slightly saline; the balance of macronutrients in the soil is determined by the position of the groundwater level; the fluctuation of the groundwater level determines the content of Ca, Mg, Na and the pH of the soil and has a significant impact on the mechanical components of the soil; moisture and drying of the soil affect the redox processes.

Conflict of Interest

None declared.

Конфликт интересов

Не указан.

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