DEVELOPMENT OF IRRIGATION REGIME USING WATER-SAVING TECHNOLOGIES IN RICE CULTIVATION

Qutlimurotov Javlonbek Qadamovich

1st year doctoral student of the Research Institute of Irrigation and Water Problems

Abstract: The results of research on the development of less water-intensive rice irrigation technology with periodic irrigation, allowing to reduce the cost of irrigation water in 3-5 times are presented. This irrigation technology solves a number of environmental problems associated with the formation of water deficit in the sources of irrigation, the water table rise, salinization, waterlogging, acidification and utilization of polluted waste and drainage water.

Keywords: *Main indicators of rice photosynthetic activity, irrigation technology solves a number of environmental problems associated with the formation of water deficit in the sources of irrigation, the water table rise, salinization, waterlogging.*

1. Introduction

Rice is one of the top three food crops. It is grown mainly in irrigated lands with continued basin flooding of water sheet, the flow of which is 20,000 m^3/ha or more [1-3]. This is the most common and water- intensive crop of irrigated land resources, although it requires less than 7,000–9,000 m^3/ha for evapotranspiration [1-3]. The main share of the rice field feed water is lost in deep filtration, side outflow [4,5], planned and spontaneous discharge of water, forming a stream of drainage and waste water with a high content of minerals and soluble herbicides, fertilizers and other pollutants. An equally important problem is the shortage of fresh water [6,7,8], which resulted from the large volume of water intake for rice irrigation. It created a serious problem with the disposal of discharged and drainage water [9,10].

2. Conditions and methods

Experimental studies were conducted in 2013-2015 in the Volgograd region at the experimental site of the Federal State Budgetary Scientific Institution "All-Russian Research Institute of Irrigated Agriculture". Rice was sown when heating the soil to 13^0C in late April - early May. Drop lines were laid through 0.6 m, the distance between the droppers was 0.33 m. The water flow through the dropper was 2.2 l/h. The soil is light chestnut, the humus content is 1.6-1.8%, the smallest moisture capacity of

0.6 m layer is 23.8% of dry soil mass, the layer-by-layer porosity of the meter profile is 46.64-51.59%. Concerning the precipitation frequency, the vegetation period of the year 2013 is characterized as wet, 306.9 mm, the year 2014 - medium dry, 104.9 mm and the year 2015 - medium wet, 235.4 mm.

The scheme of the two-factor experiment included 3 options for the soil water regime. Option A1 - allowable decrease in the moisture content of the active layer (0.6 m) of soil 80% HB; A2 - until the end of the tillering stage of rice according to variant A1 in a layer of 0.4 m with a subsequent increase in the layer to 0.6 m; A3 - water mode for option A2 before the beginning of the wax ripeness of the grain, followed by a decrease in pre-irrigation moisture to 70% HB. The second factor, the rate of fertilizer, in variant B1 to obtain a yield of 5 t/ha of grain (N109 P62 K75); B2 - 6 t/ha (N131 P74 K90) and B3 - 7 t/ha (N157 P90 K108) tones of grain per 1 ha.

The experiments were held by the method of split plots with single-tier systematic placement of options for the water regime and randomly - with rate of fertilizer application in three replications with the observance of standard methods of the experiments [11-13].

3. Results and discussion

The soil moisture content according to variant A1 was ensured by carrying out irrigations with a norm of 370 m^3/ha over the years 2012, 15 and 13 respectively. The irrigation rate was 4440, 5550 and 4810 m^3/ha. The duration of inter-irrigation periods in different phases of development varied from 2 to 26 days. In variant A2, 4, 5 and 2 irrigation at a rate of 250 m^3/ha and 10, 13 and 13 irrigation at a rate of 370 m^3/ha were required. The volume of water supplied to the field for all irrigations changed in this way: 4700, 6060 and 5310 m^3/ha with duration between irrigations from 2 to 19 days. To maintain the water regime for option A3, it took 4, 5 and 2 irrigations at a rate of 250 m^3/ha, 8, 10 and 10 irrigations at a rate of 370 m^3/ha and one irrigation at a rate of 550 m^3/ha. The total costs of irrigation water for growing rice in this variant were 4510, 5500 and 4750 m^3/ha.

The effect of different water regimes of the soil in combination with the application of fertilizers N131 P74 K90 and A3 with different rate of fertilizers was estimated by the reaction of rice plants with indicators of their photosynthetic activity (Table 1).

Judging by the indices of photosynthetic activity, the reaction rates of rice in all variants of the soil water regime were quite high. But the best ones were formed in the water mode of variant A2, and the lowest in A1. Experiments have established a sufficiently high reaction of rice plants to the rate of fertilizers. Within the limits of the accepted scheme of experiments and the variants of applying the rate of fertilizers, the reaction of plants to their increase was positive, judging by the photosynthetic activity and yield of rice.

Table 1. Main indicators of rice photosynthetic activity (average during the period from 2013 to 2015)

Experiment variants	**Maximum leaf area, thousand m^2/ha**	**Net photosynthesis productivity, r/m^2 a day**	**Photosynthetic potential, thousand m^2 days/ha**	**Crop yield, t/ha**
A1 + N131 P74 K90 (B2)	35.56	5.91	2180/66	5.70
A2 + N131 P74 K90 (B2)	36.78	6.22	2385.29	6.23
A3 + N131 P74 K90 (B2)	36.42	6.16	2297.97	6.11
A3 + N109 P62 K75 (B1)	34.79	5.69	2023.04	5.13
A3 + N131 P74 K90 (B2)	36.42	6.16	2297.97	6.11
A3 + N157 P90 K108 (B3)	37.64	6.47	2502.60	6.87

The obtained results on the dynamics of rice yields in the water regime and fertilizer rate allowed us to recommend their combination for obtaining yields of 5, 6 and 7 t. of grain per hectare (Table 2).

Table 2. Combination of anthropogenically-regulated factors to obtain the planned

yield of rice (average for 2013-2015)

Yield, t/ha grain		Deviation from planned norm, %	Combination of factors		Irrigation norm, m^3/ha	Costs of irrigation water, m^3/t
planned	real		soil water regime	mineral fertilizers rate, kg of rate application/ha		
5	4.88	-2.40	A1	N109 P62 K75	4933	1011
	5.29	+5.80	A2		5357	1013
	5.13	+2.60	A3		4920	959
6	5.70	-3.00	A1	N131 P74 K90	4933	854
	6.23	+3.80	A2		5357	860
	6.11	+1.83	A3		4920	805
7	6.64	-5.10	A1	N157 P90 K108	4933	743
	6.95	-0.71	A2		5357	771
	6.87	-1.86	A3		4920	716

Analysis of rice yields data on the systems of drop irrigation at different water regimes of the soil and the rate of fertilizer allowed to establish a relationship between the photosynthetic potential and yield, which is described by the level of PP = 5.9567, U2 + 204.86, U + 815, $R^2 = 0.98$ (Figure 1).

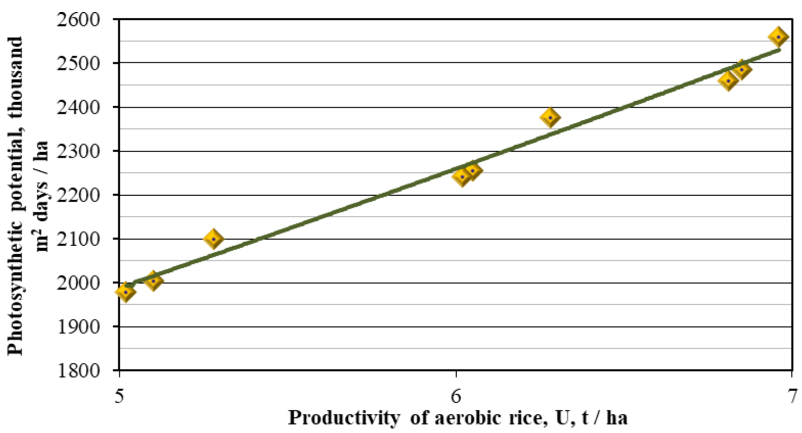

Figure 1. Indicators of photosynthetic potential, providing different, in the intervals of 5-7 t/ha of rice grain (average for 2013-2015).

Using this equation allows us to predict the main yield-forming characteristics of agrocenosis for obtaining the planned yield of rice. From the data of table 2 it can be seen that the planned yield of 5 t/ha is possible in all variants of the water regime of the soil when combined with the application of fertilizer N109 P62 K75. However, variant A3 was the least water consuming per ton of grain. The yield of 6 t/ha of grain was also formed in all variants of the water regime, but on the background of a higher rate of fertilizers N_{131} P_{74} K_{90}. And although all the variants in the water regime of the soil have not so large deviations in terms of the costs of irrigation water for crop formation, the most preferred option is still A3. The average 3-year crop yield of rice with a deviation of 0.71% from the planned level of 7 t/ha was obtained by combining the A2 water regime with adding N_{157} P_{90} K_{108}. However, the least water-intensive one for the production of 1 ton of grain (715 m^3) was the irrigation regime of rice according to variant A3 with the addition of N_{157} P_{90} K_{108}.

The relationship between the evapotranspiration rate and irrigation water costs is established with the levels of yield generated by aerobic rice, which is expressed by the approximate equations $Kv = 21.623 \cdot U^2 – 432.13 \cdot U + 2895.5$ and $Kw = 18.23 \cdot U^2 – 355.18 \cdot U + 2322.5$, where Kv is the evapotranspiration ratio of rice, m^3 of evapotranspiration per 1 ton of rice grain; Kw is the irrigation water cost ratio for obtaining 1 ton of rice grain; U - rice yield, t/ha of grain (Figure 2).

4. Conclusion

Cultivation of rice on drop irrigation systems, as well as, as our studies of earlier years and other authors' researches showed, when irrigating by strip and sprinkling with the use of aerobic and tolerant to the absence of a layer of water in checks. The development of less water-intensive rice irrigation technology with periodic irrigation allows to reduce the costs of irrigation water by 3–5 times or more and to cultivate this crop on general-irrigation systems in field, forage, vegetable and other crop rotations.

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