The effectiveness nitrogen balance urea cotton using nitrification inhibitor washed typical sierozems

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Abstract. In the conditions of the sierozem zone soils, where the nitrogen content is relatively low, nitrogen fertilizers play the leading role among the fertilizers used for cotton. Nitrogen losses due to washout, denitrification, etc., during the growing season can reach 50% or more, and therefore the study of the effect of the nitrification inhibitor KMP on the efficiency of nitrogen fertilizers and the nitrogen balance using the nitrogen isotope 15N when applying urea for cotton is of great importance. Small-plot and field experiments with cotton were carried out on irrigation-eroded washed-out typical sierozem and were laid in the upper part of the slopes of the massifs. Nitrogen was applied against the background of RK in the form of urea enriched with 15N - 23-25%. The use of nitrification inhibitors with urea and slow-release fertilizers increased the use of fertilizer nitrogen to 38.1%, fixation of fertilizer nitrogen in the soil from 21.4 to 29.3%, reduced nitrogen losses with waste water and as a result of washout from 10.3 to 4.5%. Losses of fertilizer nitrogen due to washout and volatilization decreased from 35.8 to 19.6%.

1 Introduction

The application of nitrogen fertilizers together with nitrification inhibitors ensured a decrease in the number of additional fertilizing during the growing season of plants by 1-2 and made it possible to reduce the annual fertilizer rate by 25-30%, while the use of soil nitrogen by plants decreased by 6-7%. Nitrogen is the most important element of mineral nutrition of plants and in the soils of the Zarafshan Valley it is in the first minimum, correlating with the humus content, which generally does not exceed 1%. [1,2]. The need of agricultural crops for nitrogen is met by nitrogen fertilizers, the application of which is a necessary condition for maintaining the yield of agricultural crops, but it is often accompanied by nitrogen losses, which harm the environment, and in economic terms, excessive costs for farmers [3].
One of the ways to increase the efficiency of nitrogen fertilizers is the use of nitrification inhibitors. By slowing down the nitrification process, they help reduce nitrogen losses, both in gaseous form and from nitrate leaching, thereby eliminating the risk of nitrate pollution of water sources [4-10]. Studies using the stable isotope 15N are the most accurate method in

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studying the nitrogen cycle in the soil-fertilizer-plant system and establishing the degree of efficiency of nitrogen fertilizer application for various agricultural crops [3,8,10].

To date, there are many publications reflecting the results of studies related to the study of the nitrogen balance of fertilizers, its transformation and movement in soils, the extent of biological fixation of atmospheric nitrogen and a number of other issues [8-20]. Analysis of published works showed that the efficiency of nitrification inhibitors on eroded gray soils has not yet been studied enough. Of the studies conducted on gray soils, the results of microfield experiments in lysimeters or vessels have been published [5, 9].

In this regard, the purpose of our studies was to study the efficiency of nitrogen fertilizers when used together with a nitrification inhibitor for cotton on irrigated-eroded gray soil using the isotope 15N.

2 Research methodology

Small-plot field experiments with cotton were laid out in the upper part of the slopes of the massifs, where full-size (plot area 200 m^2) field experiments with the same crop were also carried out on a typical washed-out sierozem (Table 1). Nitrogen was applied against the background of RK in the form of urea enriched with 15N - 23-25%. Labeled urea was applied manually, trying to simulate the application of nitrogen fertilizers in field conditions as much as possible, in the lateral parts of the ridge to a depth of 10-15 and 20-25 cm.

Table 1. Agrochemical characteristics of the arable layer of washed-out typical sierozem

Slope, °	**pH**	**Humus content, %**	**Gross content, %**			**Content of mobile forms, mg/kg**			**Carbonate content, %**
			N	**P**	**K**	**N**	**P_2O_5**	**K_2O**	
3	7.2	0.6	0.06	0.13	1.8	12-18	28.32	180-200	12-14

Plots of 120×100 cm were placed in 1 tier across the slope, with the long side across the furrows. Thus, 2 rows of cotton were fertilized only with labeled urea. The experiments were repeated 4 times, the variants with labeled nitrogen were laid out in 2 replicates. Drainage sites were equipped in the furrows between 2 rows fertilized with labeled urea. Total nitrogen was determined using a mass spectrometer. In all plots (corresponding variants), 1-carbamoyl-3(5)-methylpyrazole (CMP) was used at a dose of 3 kg/ha. Thus, the scheme of small-plot experiments with nitrogen-15 represents fragments of more complete schemes of field experiments. The removal of nutrients from the soil by cotton was calculated by determining the biomass of plants and the NPK content in it. The amount of NPK in plants was determined using the Ginzburg method from one sample [21]. The yield was determined using the method of using accounting plots on each plot, and then recalculated per hectare. In parallel, the efficiency of mineral fertilizers was calculated using the difference method [21]. The data were processed using the dispersion analysis method in accordance with the methodology described in [22-52].

3 Results

The research showed that the yield in the corresponding variants of small-plot and full-size field experiments was very close (Table 2). The results of the field experiment (Table 2) showed that a decrease in the nitrogen dose from 220 to 165 kg/ha, when using nitrification inhibitors, did not affect the cotton yield (variants 2 and 5). Application of the entire dose of nitrogen in the phase of 3-4 leaves sharply reduced the yield of raw cotton, compared to the adopted fractional method of application (variants 6 and 4).

Table 2. Cotton yield in field and small-plot experiments, c/ha.

№	Variations	Field experience	Small-scale plot experiment
1	Background-PK	17.9	20.5
2	Background + Nm 220	33.8	33.0
3	Background + Nm 220 + IN	37.9	-
4	Background + Nm 165	29.6	-
5	Background + Nm 165 + IN	32.9	-
6	Background + Nm 165 one-time	24.6	25.2
7	Background + Nm 165 one-time + IN	31.5	33.3
8	NSR	3.7	3.0

At the same time, the combination of a single application of a reduced dose of nitrogen with the application of a nitrification inhibitor increased the cotton yield to the level of the yield in the variant with the fertilization system adopted in the region (variants 7 and 2). To clarify the reasons for such a high efficiency of relatively low (for cotton) doses of nitrogen, moreover, with a single application of the entire dose, we conducted a small-plot experiment, in which, in addition to 2 variants with labeled nitrogen, we introduced a nitrogen-free (background) variant of RK and a variant with a nitrogen dose of 220 kg/ha, applied fractionally, according to the adopted fertilization system (Table 3).

Table 3. Effect of nitrification inhibitor on nitrogen balance of labeled urea in a small-plot experiment with cotton.

Variations	Raw cotton yield, c/ha	Nitrogen removal, kg/ha		Use of nitrogen fertilizers, % of applied			
				difference method		isotope method	
		*1	*2	**1	2	1	2
Background-PK	20.5	101.1	76.0	-	-	-	-
Urea labeled, single, N165	25.2	158.5	120.5	34.8/57.4	27.0/44.5	26.0/42.9	20.4/33.7
Urea labeled, single, N165+IN	33.3	194.2	149.4	56.4/93.1	44.5/73.4	48.9/80.7	39.1/64.5
Urea unlabeled, N220	33.0	201.3	150.1	45.5	33,7	-	-
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	Remained in the soil	**Washed away**	**Unaccounted losses (washing + evaporation))**	**Remained in 0-50 cm soil layer (in roots + soil))**	**Removed from 0-50 cm soil layer (above-ground mass + washout + unaccounted losses)**
Background-PK	-	-	-	-	-
Urea labeled, single, N165	25.2/41.6	12.8/21.1	36.0/59.4	30.8/50.8	69.2/114
Urea labeled, single, N165+IN	34.1/56.3	5.3/8.7	11.7/19.3	43.9/72.5	56.1/92.5
Urea unlabeled, N220	-	-	-	-	-

In table 3:
*1 – removal and use of nitrogen by the entire vegetative mass of plants
*2 – removal and use of nitrogen by the aboveground mass of plants.
**in the numerator – % of applied, in the denominator – kg/ha.

The cotton yield, its removal of total nitrogen, and the use of fertilizer nitrogen by plants (difference method) confirmed the results obtained in the field experiment. The introduction of a nitrification inhibitor against the background of N165 increased the raw cotton yield from 25.2 to 33.3 c/ha, increasing the removal of total nitrogen by the aboveground mass from 121 to 149 kg/ha. The use of fertilizer nitrogen increased from 27.0 to 44.5%. For all the considered indicators, there were no differences in absolute values between variants 3 and 4. The use of an isotope label made it possible to establish a 2-fold increase in the use of fertilizer nitrogen (from 20.4 to 39.1%) by the aboveground mass of cotton when introducing a nitrification inhibitor. Such an increase in the use of fertilizer nitrogen indicates a significant improvement in nitrogen nutrition of plants when introducing a nitrification inhibitor. This is explained by a longer retention of a larger amount of fertilizer nitrogen in the root zone of the soil. Thus, 5.3% of the applied fertilizer nitrogen was carried away from the plot with solid runoff and waste water in the variant with a nitrification inhibitor, while in the variant without a nitrification inhibitor it was 12.8%, and the losses of fertilizer nitrogen from denitrification also decreased. The sum of these losses, determined by the difference between the amounts of nitrogen applied and found in plants, soil and runoff, decreased with the application of a nitrification inhibitor by 3 times from 36.0 to 11.7%. It is interesting that nitrification inhibitors, improving nitrogen nutrition of cotton, did not affect the assimilation by plants of additionally mobilized soil nitrogen (extra nitrogen), formed when nitrogen fertilizers are applied to the soil. The studies showed that the plants absorbed 6-7% of the "extra nitrogen", and in the variant with the nitrification inhibitor, 9% more fertilizer nitrogen was fixed in the soil. Together with the fertilizer nitrogen remaining in the plant roots and not removed from the field, 43.9 and 30.8% of the applied fertilizer nitrogen remained in the half-meter sierozem layer in these variants, respectively. The opposite picture is observed when taking into account the fertilizer nitrogen removed from the same soil layer with the above-ground mass of cotton, solid runoff, waste water, losses due to leaching and volatilization. The sum of these balance items for the considered variants was 69.2 and 56.1%, respectively. The use of nitrification inhibitors increased the cotton yield due to the improvement of the nitrogen regime of the soil.

The result of changing the structure of the fertilizer nitrogen balance when applying the nitrification inhibitor was a more economical consumption of soil nitrogen by plants due to an increase in the consumption of nitrogen from the applied urea. With an increase in cotton yield by 8.1 c/ha of raw cotton, the removal of total soil nitrogen by plants in the compared variants was the same: 115.6 kg/ha without an inhibitor and 113.5 kg/ha with an inhibitor (Table 4). The share of soil nitrogen and fertilizer in the removal of total nitrogen by the entire vegetative mass of cotton in these variants was 72.9 and 27.1% and 58.4 and 41.6%, respectively.

Table 4. Effect of nitrification inhibitor (NI) on the use of soil nitrogen and fertilizer by cotton.

Nitrogen dose, kg/ha	Вариант	Total nitrogen removal by the entire vegetative mass of plants, kg/ha	Nitrogen fertilizers		Soil nitrogen	
			kg/ha	% of removal	kg/ha	% of removal
105	without IN	158.5	42.9	27.1	115.6	72.9
	with IN	194.2	80.7	41.6	113.5	58.4

The results obtained in the experiments with cotton showed that the use of a nitrification inhibitor allowed not only to obtain a high yield of raw cotton with a significant reduction in the applied dose of nitrogen fertilizer, but also to improve the nitrogen regime of the sierozem soil, reduce the loss of soil nitrogen and fertilizer, and contributed to better conservation of soil nitrogen reserves.

4 Conclusion

In small-plot experiments with cotton on irrigation-eroded typical sierozem of the Samarkand region, the same efficiency of using a nitrification inhibitor was noted as in field experiments. The use of a nitrification inhibitor against the background of a single application of the entire dose of nitrogen fertilizer increased the cotton yield from 24 to 33 c/ha. Experiments with the stable isotope 15N have shown that when cultivating cotton under irrigation, the loss of nitrogen from mineral fertilizers ranges from 30 to 40% of the amount applied, and the coefficient of utilization of nitrogen from fertilizers from the soil is 25-35.8%. The use of nitrification inhibitors with urea and slow-acting fertilizers increases the use of nitrogen from fertilizers to 38.1%, the fixation of nitrogen from fertilizers in the soil from 21.4 to 29.3%, the loss of nitrogen with waste water and as a result of washout decreased from 10.3 to 4.5%, and the amount of "extra nitrogen" used by plants amounted to 8.9-9.1 kg/t. The loss of nitrogen from fertilizers due to washout and volatilization decreased from 35.8 to 19.6%. The introduction of nitrogen fertilizers with nitrification inhibitors ensures a reduction in the number of additional fertilizing during the growing season of plants by 1-2, depending on the length of the growing season of plants, allows to reduce the annual fertilizer rate by 25-30% and ensures an increase in the dose of nitrogen fertilizers in the total removal of plants from 27-42% to 42-51%, while the use of nitrogen in the soil by plants is reduced by 6-7%.

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