The effect of crop rotation on productivity and grain quality of Alexeevich winter wheat

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Abstract. The article identifies the optimal crop rotations to improve soil fertility in the moderately saline meadow-alluvial soils of Bukhara region and to produce a high and quality grain yield of the new Alexeevich variety of winter wheat. It provides a detailed analysis of the effects of crop rotations on the grain yield of winter wheat of the new Alexeevich variety, including yield components such as average ear length, number of grains per ear, grain mass per ear, yield and quality indicators—glassiness, protein, gluten, gluten index (GI), thousand-grain weight, grain bulk density, and overall bread-making quality score. In the control variant (fallow without crop rotation), the average grain yield was 60.6 c/ha. When winter wheat was planted after crop rotations with grain sorghum (for silage), maize (for silage), and white maize (for silage), the grain yield increased by 3.9 to 7.0 c/ha, reaching 64.5, 66.5, and 67.6 c/ha, respectively, compared to the control. When winter wheat was sown after legumes such as beans and mung beans, the grain yield reached 70.2–71.4 c/ha, which is 9.6–10.8 c/ha higher than the control (fallow without crop rotation). Based on the experimental results, recommendations have been made for agricultural production.

1 Introduction

In the soil and climatic conditions of our country, it is possible to obtain a second and even third harvest by sowing repeated, fallow, and autumn intermediate crops on fields left vacant after the main cereal crops sown in autumn [1-3]. Traditionally, farmers have allocated land for repeated and fallow grain crops such as sorghum, mung bean, and white maize on fields left vacant after autumn-sown wheat and barley [4-7].

According to B. M. Khaliqov, continuous cultivation of winter wheat on the same field over many years leads to a decrease in grain yield regardless of the type and amount of fertilizers used. This is because crop rotation plays an irreplaceable role in producing higher and quality grain from winter wheat [8].

Including grain and legume-grain crops as repeated crops in crop rotation systems serves, firstly, to preserve and improve soil fertility, and secondly, to meet the growing demand for

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grain products due to the increasing population. Moreover, many researchers have conducted studies on the effects of repeated, intermediate, grain, legume-grain, and cereal crops, and their root and stubble residues on soil fertility [4; 5;].

Unlike other cereal crops, winter wheat is very demanding on previous crops. Growing it intensively on the same field for 2–3 consecutive years leads to a sharp decrease in grain yield. Therefore, in order to maintain and improve the fertility of moderately saline meadow-alluvial soils of Bukhara region, as well as to ensure high-quality and high-yielding winter wheat production, it is important to select optimal repeated crops and develop scientifically based agrotechnologies for their cultivation.

2 Material and research methodology

Field experiments on the effect of repeated crops on winter wheat yield under the conditions of moderately saline meadow-alluvial soils of Bukhara region were conducted on medium-textured soils at the "Narzi Oyim" farm located in the Olot district during 2019–2022. The objects of study were repeated crops grown on irrigated lands, including the grain sorghum variety Saratovskoe 853, maize hybrid Moldavskiy 215 AMV, bean variety Ravot, mung bean variety Turon, white maize variety Uzbekistan 5, and the new winter wheat variety Alexeevich, all registered in the State Register.

The field experiments included six variants, arranged in four replicates in a two-tier system. Each plot measured 80 m in length, 90 cm in row spacing, and 3.6 m in width, with a single plot area of 288 m², resulting in a total experimental area of 6912 m².

All phenological observations and biometric measurements in the field experiment were conducted following the methodological guidelines and yield data obtained were analyzed using analysis of variance [1, 2; 3].

3 Results and Discussion

The research revealed that different types of repeated crops had a significant effect on the number of grains per ear, the average length of the ear, and the grain mass per ear in winter wheat (see Table 1). When analyzing the impact of repeated crops on yield components, it was found that in the control plots, the grain mass per ear was 1.25 g. Among the repeated crops, the lowest grain mass per ear was observed after sorghum, amounting to 1.26 g. Depending on the type of repeated crop, the grain mass per ear varied from 1.26 to 1.29 g. The lowest grain mass per ear was recorded in the variant where winter wheat was sown after sorghum, and the highest—after mung bean—with 1.29 g.

The number of grains per ear in winter wheat is an indicator that varies depending on the type of repeated crop and the applied agrotechnology.

In the experiments, the number of grains per ear ranged from 34.0 to 35.5 depending on the type of repeated crop. The highest number of grains per ear was recorded after mung bean, and the lowest—after sorghum. Winter wheat productivity is a complex indicator that depends on many factors, including the preceding crop, climatic conditions, water and light availability, nutrient regime, applied technological methods, and the biological characteristics of the variety [6].

The cultivation technology must ensure optimal satisfaction of the plant's vital needs during each stage of organogenesis. Each environmental factor or applied technological measure has a significant effect on both yield and grain quality of winter wheat.

In the experiment, compared to the control variant (fallow without repeated crop), the grain yield increased by 3.9 centners/ha when sorghum was the preceding crop, by 5.9 c/ha after maize (for silage), by 9.6 c/ha after beans, by 10.8 c/ha after mung bean, and by 7.0 c/ha after white maize (for silage). These increases in grain yield can be explained by the higher content of nutrients in the soil's root and stubble residues in the variants with repeated crops (see Table 2).

Table 1. Effect of repeated crops on the formation of winter wheat yield components (2020–2022)

№	Variants	Average ear length (cm)	Number of grains per ear (pcs)	Grain mass per ear (g)
1	Control (fallow without repeated crop) + winter wheat	8.1	34.0	1.25
2	Sorghum + winter wheat	8.1	34.4	1.26
3	Maize (for silage) + winter wheat	8.2	34.6	1.27
4	Bean + winter wheat	8.3	35.2	1.28
5	Mung bean + winter wheat	8.3	35.5	1.29
6	White maize (for silage) + winter wheat	8.2	34.8	1.27

Table 2. Effect of repeated crops on winter wheat grain yield (c/ha)

№	Variants	Years	Average yield (c/ha)	Additional yield due to repeated crop (c/ha)
		2020	2021	2022
1	Control (fallow, no repeated crop) + winter wheat	62.4	58.7	60.7
2	Sorghum + winter wheat	66.2	63.1	64.2
3	Maize (for silage) + winter wheat	68.6	64.7	66.2
4	Bean + winter wheat	72.3	68.4	69.9
5	Mung bean + winter wheat	73.8	69.6	70.8
6	White maize (for silage) + winter wheat	68.8	66.3	67.7

$LSD_{0.5}$ (Least Significant Difference), c/ha = 2.20 (2020); 1.95 (2021); 2.05 (2022)
$S\bar{x}$ % (Coefficient of variation) = 1.35 (2020); 1.20 (2021); 1.29 (2022)

It was found that the most optimal repeated crops—bean and mung bean—had a positive effect on winter wheat yield due to the organic matter left in the soil in the form of root and stubble residues. When winter wheat was sown after these legumes as repeated crops, the average grain yield ranged from 70.2 to 71.4 c/ha, exceeding the control variant (fallow without repeated crop) by 9.6–10.8 c/ha. Among all studied variants, mung bean was identified as the most optimal preceding crop, with an average yield of 71.4 c/ha over the years of the experiment (Table 2).

The yield indicators of winter wheat were significantly influenced by repeated crops, weather conditions, and the type of preceding crop. Leguminous grain crops such as bean and mung bean provided the highest yield when used as preceding crops.

One of the reasons for the decrease in winter wheat productivity is continuous wheat cultivation on the same plot, which leads to the accumulation of soil-borne pests, fungal pathogens, and weed seeds.

According to D.T. Abdukarimov, if leguminous crops are planted as repeated crops after harvesting winter wheat, it is possible to obtain two grain harvests in one year. Additionally, this practice helps increase soil fertility and reduce weed infestation [4].

R. Tillaev and A. Mansurov emphasized that including leguminous grain crops in short rotation systems as repeated crops after winter wheat helps produce high-quality seed grain and supports the economic development of farming enterprises [8].

The physical quality indicators of winter wheat grain include vitreousness (glassy grain percentage), grain bulk density (g/L), and 1000-grain weight. Research results showed that depending on the type of repeated crop, the 1000-grain weight ranged from 41.0 to 42.1 g. The highest 1000-grain weight was recorded in the variant where winter wheat followed mung bean (see Table 3).

In the experiments, the vitreousness of the grain varied between 59% and 65%, depending on the repeated crop. The highest vitreousness (65%) was also observed in the winter wheat grown after mung bean.

Regarding bulk density, the grain's natural weight (test weight) ranged from 810 to 825 g/L, depending on the preceding crop. It was observed that the bulk density of grain from the control variant (fallow without repeated crop) was lower compared to that of plots sown after repeated crops.

In the experiments, it was observed that the key quality indicators of winter wheat grain—protein and gluten content—varied depending on the type of repeated crop. The protein content in the grain was found to be lower in the control plots (fallow, no repeated crop) compared to those where repeated crops were used, ranging from 12.8% to 13.2%.

Protein content is closely correlated with gluten content, which is a critical technological parameter of wheat grain. In the experiments, gluten content in winter wheat grain varied from 27.3% to 30.2%, depending on the type of repeated crop. Specifically, repeated crops such as bean and mung bean contributed positively, increasing gluten content by 2.3% and 2.9%, respectively, compared to the control.

The effect of repeated crops on the yield and quality of winter wheat is directly related to the moisture and nutrient regime of the soil, its granular structure, agro-physical and chemical properties, and the activity of microbiological processes. The study revealed that planting repeated crops contributed to the improvement of chemical and agro-physical properties, as well as microbiological activity of the soil. As a result, the technological quality parameters of winter wheat grain improved significantly (see Table 3).

Table 3. Effect of Repeated Crops on Technological Quality Indicators of Winter Wheat Grain (2020–2022)

№	Variants	Vitreousness (%)	Protein (%)	Gluten (%)	IDK Indicator	1000 Grain Weight (g)	Grain Test Weight (g/L)	Overall Bread-Making Score (points)
1	Control (no repeated crop) + winter wheat	59	12.8	27.3	90	41.0	810	3.2
2	Millet + winter wheat	61	12.9	27.5	85	41.1	812	3.4
3	Maize (for silage) + winter wheat	62	13.0	27.7	85	41.5	820	3.6
4	Bean + winter wheat	64	13.1	29.6	75	42.0	824	3.8
5	Mung bean + winter wheat	65	13.2	30.2	75	42.1	825	3.8
6	White sorghum (for silage) +	62	13.0	28.2	80	41.3	815	3.

№	Variants	Vitreousness (%)	Protein (%)	Gluten (%)	IDK Indicator	1000 Grain Weight (g)	Grain Test Weight (g/L)	Overall Bread-Making Score (points)
	winter wheat							

4 Conclusion

In summary, under the meadow-alluvial soil conditions of Bukhara region, mung bean and common bean were identified as the most effective repeated crops. When winter wheat was sown following these crops, the grain yield structure elements improved, and grain productivity increased significantly compared to the control variant (fallow land without repeated crops). As a result, an additional 9.6–10.8 centners per hectare of grain yield was obtained.

Moreover, grain quality indicators also improved:

- Grain vitreousness increased by 5–6%
- Protein content increased by 0.3–0.4%
- Gluten content increased by 2.3–2.9%
- Thousand kernel weight increased by 1.0–1.1 g
- Test weight (hectoliter weight) increased by 14–15 g
- Overall bread-making quality score increased by 0.6 points

Additionally, the content of carbohydrates, oils, minerals, and fiber in the grain also showed a noticeable improvement.

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