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The Influence of Sowing Rate on the Yield and Grain Quality of Winter Wheat and the Impact in Akhaltsikhe Conditions

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Abstract: A study on the influence of sowing rates on the yield and grain quality of winter wheat varieties was conducted in the climatic zone of Akhaltsikhe. Among the tested varieties of winter soft wheat—Akhaltsikhe Red Doli, Tbilisuri 15, and Sauli 9—the latter two stood out for their yield and grain quality. Under Akhaltsikhe conditions, their yield exceeded the control (Akhaltsikhe Red Doli) by 0.4 t/ha. At the same time, the protein content in the grain of Tbilisuri 15 and Sauli 9 winter wheat exceeded the control by an average of 0.2–1.1%, while the gluten content was 0.6–3.9% higher. For all winter wheat varieties in the study region, the 1000-grain weight and test weight (hectoliter weight) were best when sowing 5 million viable seeds per hectare. According to the research results, the optimal sowing rate for achieving high yields of high-quality grain is 4–5.0 million viable seeds per hectare.

Keywords: *Winter Wheat, Variety, Sowing Rate, Yield, Grain Quality.*

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I. INTRODUCTION

In the complex of agronomic measures aimed at increasing the yield and grain quality of winter wheat, sowing rates play a significant role. With the emergence of new, high-yielding varieties of winter wheat, these issues require additional study, which depends on the soil and climatic conditions of ecological zones [3].

The basic requirement of sowing rates is to ensure an optimal number of plants and productive stems per unit area. To achieve this, they are determined based on the agricultural background, sowing time, biological characteristics of the variety, and soil-climatic conditions. Successful agrotechnology of winter wheat in Akhaltsikhe Municipality is possible only by developing a strictly differentiated agricultural system. The aim of our research is to study the reaction of new winter wheat varieties to changes in sowing rates in the Akhaltsikhe agro-climatic zone [2; 4; 8; 9].

II. CONDITIONS, MATERIALS, AND METHODS

The soil and climatic conditions of Akhaltsikhe are quite diverse in terms of climate, vegetation, and soil cover.

Akhaltsikhe is located at an altitude of 1000 m above sea level and is characterized by insufficient humidity and continental, hot climate. Most of Akhaltsikhe Municipality has mountain steppe climate, with cold winters with little snow and long, warm summers. At the bottom of Akhaltsikhe

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depression, the average temperature in January is -3.8°C and in August 20.5°C. In the higher zone, on the Meskheti Range, the climate transitions from humid to moderately humid continental. In the ridge zone of the Erusheti Range, there is a mountain steppe climate with short summers and cold winters. Precipitation does not exceed 520 mm per year in the lower zone, while it does not reach 1200 mm on the slopes of the bordering ranges. The maximum precipitation occurs in May (64 mm) and June (86 mm), and the minimum in the winter months (January 20 mm, February 25 mm). The average annual air temperature is 7.3–8.4°C, while precipitation ranges between 440–719 mm. The soil cover consists of leached mountain chernozems, mountain-steppe, and mountain-meadow soils [5; 6; 7].

Experimental work was carried out at the Samtskhe-Javakheti State University research facility from 2020 to 2023. The objects of study were winter wheat Tbilisuri 15 and Sauli 9, developed at the Scientific-Research Center of Agriculture of Georgia by Ts. Samadashvili. The local variety Akhaltsikhe Red Doli was taken as a control. The preceding crop was silage maize. The test was conducted on three sowing rates for the winter wheat varieties: 4.0, 5.0, and 6.0 million viable seeds per hectare.

Grain quality assessment was conducted in accordance with the "Methodological Recommendations for Assessing Grain Quality" in the Laboratory of Biological Research and Chemical Analysis. The agrotechnology for growing winter wheat varieties followed generally accepted standards for the Republic's zones. The experimental plot area was 50 m^2, with three replications. The general fertilizer background was $N_{60}P_{60}K_{30}$. Phosphorus and potassium were applied to the plot before sowing, while ammonium nitrate was added as a top dressing at a rate of 60 kg of active substance [1; 2].

During the research years (2020-2023), weather conditions and soil moisture regimes were favorable for the growth, development, and overwintering of winter wheat.

III. CHARACTERISTICS OF EXPERIMENTAL VARIETIES

- *Akhaltsikhe Red Doli Bread*

Variety description: An ecotype of the local Meskheti mountain-plain species, an ancient local variety. Botanical name: *Triticum aestivum var. ferrugineum Alef* . The distribution of Akhaltsikhe Red Doli reaches up to 1500 meters above sea level. It is a winter-hardy, late-maturing variety. It was formed in Meskheti and partially in Javakheti. It is adapted to the mountain-forest-steppe zone and moves into the mountain-steppe zone as well. Red-headed forms predominate in Meskhetian populations, and the coloring of the head is particularly pronounced.

Use: The variety serves as breeding material; it is tall and characterized by intense coloring. It is distinguished by strong tillering, a thin stem, and moderately foliated narrow leaves. The head is red, awned, medium-sized, spindle-shaped, and nodding at maturity. The keel side of the spikelet is wider and raised. The grain is elongated-oval in shape with flinty consistency. The grain is tightly set in glumes and does not shatter; it is drought-resistant. It is resistant to fungal diseases but prone to lodging. Under optimal cultivation conditions, it yields a high and stable crop [4]. The variety has been registered since 1959 [Naskidashvili, Sikharulidze, Chernysh 1983, 59].

- *Wheat Variety Tbilisuri 15*

Triticum aestivum L. Variety characteristics: The variety belongs to the soft wheat species (*Triticum aestivum L.*) and the red-grained awnless variety—*var. lutescens Alef*. The winter wheat variety "Tbilisuri 15" was obtained by the Scientific-Research Center (LEPL Scientific-Research Center of Agriculture) by crossing "Tbilisuri 8" and "Bezostaya 1". It is distinguished by winter and drought hardiness and is characterized by high germination capacity, a strong root system, and average tillering. The number of well-developed productive heads per plant varies between 2.5 and 3.5. The maximum height of the plant is 105 cm. It is resistant to lodging, threshes easily, and is suitable for mechanized harvesting. The head is 9.5-11 cm long, with 22-25 well-developed spikelets. The grain is large and red. The average yield per hectare of "Tbilisuri 15" is 1.5-2 tons higher than that of the control varieties "Bezostaya 1" and "Jagger". Under high agrotechnical conditions, the variety's yield potential is above 7.5-8.5 t/ha, according to Scientific-Research Center data. "Tbilisuri 15" requires a high agrotechnical background for high yields [4]. it is intended for all wheat-growing regions of Georgia. Sowing per 1 ha in non-irrigated conditions is 6 million (250 kg), and in irrigated conditions, 5 million (240 kg). According to Scientific-Research Center data, the average harvested yield was 5.7 t/ha [4].

- *Wheat Variety Sauli 9*

Triticum aestivum L. "Sauli 9" (Introduced variety) is a soft wheat variety. According to its development type, it is 4-6 days earlier than the standard. The plant is erect, with a height of 95-100 cm. "Sauli 9" is characterized by high winter and drought hardiness. 4-5 heads are developed at an equal height on the plant. The head is white, awned, 12-13 cm long, with 55-60 grains per head. The 1000-grain mass is 40-44 grams. It threshes well and is suitable for mechanized harvesting. The grain is red, gluten content is 25.0%, and protein is 11%. The variety stands out for its high and stable yield. Its average yield is 5.0-5.6 t/ha. The vegetation period lasts 260-270 days [5].

IV. RESULTS

On average over three years, for the Akhaltsikhe Red Doli variety (control), the highest yield was recorded at a sowing rate of 4 million seeds per hectare - 4.2 t/ha [Table 1; Figure 1]. Tbilisuri 15 showed the best results when sowing 5.0 million grains per hectare - 5.6 t/ha, which exceeded the control by 0.4 t/ha. Under these conditions, the highest content of gluten and protein in the grain of the control variety was recorded when sowing 4.0 million seeds per hectare: 14.1% and 32.2% respectively. In the case of the Tbilisuri 15 variety, when sowing 5.0 million viable seeds per hectare, the highest gluten and protein content was 15.2% and 33.5%. For

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the Sauli 9 variety, the protein content was relatively lower across all tested sowing rates (14.4%, 14.2%, 14.1%), while the gluten content across all tested variants was 33.2%, 33.4%, and 32.5% respectively. For all studied varieties, the highest 1000-grain weight and test weight were recorded at a sowing rate of 4.0 million seeds per hectare, ranging from 35.5 to 43.5 g and 770 to 784 g/l respectively.

In the foothills zone over three years, the highest average yield was achieved with a sowing rate of 5.0 million seeds per hectare for Tbilisuri 15 and Sauli 9, reaching 5.6-5.7 t/ha. The control variant lagged behind both tested varieties in yield by 0.2 to 0.51 t/ha. Tbilisuri 15 stood out for grain quality. Its highest protein and gluten content was recorded at 5 million viable seeds per hectare - 15.2% and 33.5%, which is 0.9% and 1.1% higher than the standard. For all studied varieties, the highest unit weight and 1000-grain weight were recorded at a sowing rate of 5 million/ha [1-2].

Table 1. Yield and Grain Quality of Winter Wheat Varieties by Sowing Rates (steppe zone, 2020-2023)

Seeding rate mln/ha	Yield t/ha	Protein %	Gluten%	1000 Grain mass grams	Nature l/g
4.0	4.8	14.1	32.2	35.5	770
5.0	4.1	14.2	32.4	35.4	771
6.0	4.3	14.1	30.4	36.4	763
HCP 05	1.3	0.6	0.71	0.70	3.7
Tbilisi 15 (Triticum aestivum L.)					
4.0	5.2	15.1	33.2	43.5	784
5.0	5.6	15.2	33.5	43.4	780
6.0	4.7	15.1	32.4	40.1	763
HCP 05	1.8	0.5	0.67	0.86	3.5
Sauli 9 (Triticum aestivum L)					
4.0	5.2	14.4	33.2	40.2	776
5.0	5.7	14.2	33.4	40.4	777
6.0	4.5	14.1	32.5	38.1	766
HCP 05	1.9	0.51	0.67	0.81	3.4

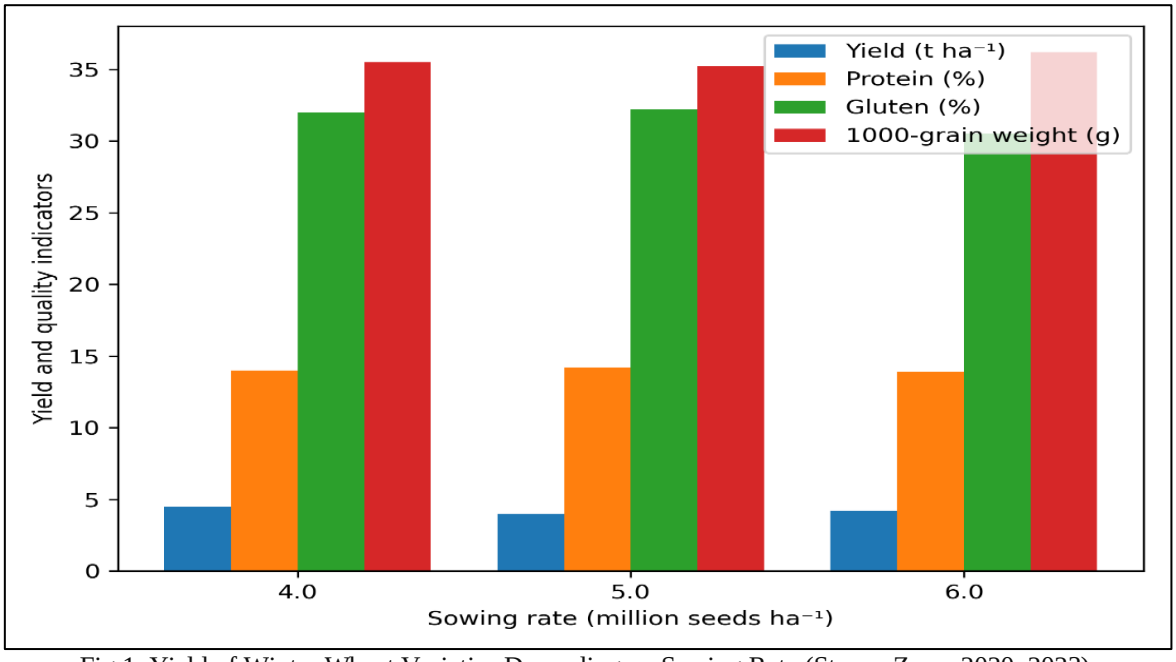

Fig 1. Yield of Winter Wheat Varieties Depending on Sowing Rate (Steppe Zone, 2020–2023).

V. CONCLUSION

The study of the influence of the sowing rate on yield in Akhaltsikhe conditions showed that the optimal sowing rate for the Akhaltsikhe Red Doli variety is 4 million seeds per hectare. In this case, a yield of 4.5 t/ha was obtained. For Tbilisuri 15, the best results in terms of yield and quality were achieved by sowing 5.0 million viable seeds per hectare (5.6 t/ha). As for the Sauli 9 variety, 5.0 million seeds per hectare can be considered the optimal sowing rate. Regarding the tested sowing rates, yields decreased in all three varieties beyond the optimum, which in the case of Akhaltsikhe Red Doli can be attributed to 4-point lodging of the crop, and in the case of Tbilisuri 15 and Sauli 9, to reduction in feeding area.

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