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**Research Article**

# Improving the Technological Techniques of Barley Cultivation for the Brewing Industry

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## ABSTRACT

This article is devoted to improving the technological techniques of malting barley cultivation and firstly to determining the optimal plant stand. Varieties of summer barley Vikont and Mamluk, approved for use in the North Caucasus region, were used as the objects of the study. The studies have allowed to establish that the barley grain grows larger and more fulfilled with the more optimal moisture supply of plants, which is especially evident with the least plant stand. It has been determined that cultivation of multirow summer barley varieties typical of the Vikont variety in the foothill area of the republic results in grain yields up to four tons with high technological properties that meet the requirements of the brewing industry. As a result of the study, it has been established that the best quality of barley grain for the brewing industry is achieved at a seeding rate of 5.0 mln viable seeds per hectare.

**Keywords:** summer barley, varieties, seeding rates, yield, technological properties, grain quality, extractivity.

## INTRODUCTION

Production of the malting barley in the republic's farms is profitable and promising. Therefore, further increase in sowing area and yield is very important. It is known that barley grain is the main raw material for the brewing industry. However, agricultural enterprises have faced some difficulties in their transition to a market economy, both in barley production and in other crops.

The malting barley grain quality depends on the plant stand, the weight of 1,000 grains and the number of them in the ear. Of these components, the yielding plant stand is the most regulated one, which in turn largely depends on the seeding rates. The optimal plant stand and the seeding rate are determined by the soil and climatic conditions of the area, biological properties of the variety, etc. [7].

Due to this, the improvement of techniques for the cultivation of malting barley and firstly for determining the optimal plant stand represents the theoretical and practical interest.

Practice reveals that malting barley grown on random fields without complying with the necessary farming techniques does not normally have high technological properties [12]. Meanwhile, the cultivation of malting barley does not differ from fodder barley in many farms. As such, high-quality raw materials are not always obtained in the required volume in farms with favorable soil and climatic conditions [10].

Experience of the leading farms and research institutions indicates actual prerequisites for the much higher quality grain cultivation than it is currently harvested in all production areas of malting barley [3].

When the numbers of productive plants of winter and summer barley are compared, winter varieties demonstrate higher yielding bushiness. This is explained by the fact that the bushiness period in winter varieties takes a longer time. It begins in the fall and continues in the spring. The hydrothermal conditions of winter crops are more favorable: the climate is temperate, the soils are provided with moisture, and the temperature is low. At the same time, climatic conditions can be unforeseen in spring, after spring sowing. The plants quickly move from one phase to another in hot, dry days. Their development is significantly ahead of the growth of vegetative organs. The formation of ears and grains occurs in not very favorable conditions, and all this together leads to a significant decrease in the grain yield. The physical properties of grains do not always meet the requirements for brewing raw materials [8]. If the spring is favorable, i.e. the hydrothermal conditions meet the biological requirements of summer barley plants, there is a natural chance to get a good harvest with high technological properties, which is very important for the production of high quality beer [13].

## OBJECTS AND METHODS

The studies were conducted in 2016-2018 in the foothill area of the KBR (Kabardino-Balkar Republic**)** at NP Shedzhem CJSC and at the Agronomy Department of the Kabardino-Balkarian SAU.

Varieties of summer barley, Viskont and Mamluk, which were approved for use in the North Caucasus region, were used as the objects of the study.

The soil of the experimental plot was leached black soil, the reaction was neutral. It contained 3.1 % of humus, 155-165 mg/kg of easily hydrolyzed nitrogen (according to Confield), 85 mg/kg of mobile phosphorus (according to Chirikov), and 100 mg/kg of exchangeable potassium (according to Chirikov). The farming technique was typical for the area [2].

The experiment was two-factor, randomized by the method of split plots, in quadruplicate, the accounting area of the plot was 50-55 $m^2$, and the total area was 60-65 $m^2$. Sowing was made by rows in the first decade of April with a seeding rate of 5.0; 5.5; 6.0 mln viable seeds per hectare. Phosphorus and potash fertilizers – superphosphate and potassium salt, 45 kg each per hectare in the fall before plowing – were applied in all cases.

## RESULTS

Average indicators of the productivity elements and grain yield of summer barley for three years are provided in Table 1.

**Table 1:** Productivity elements and grain yield of summer barley, depending on the seeding rate (2016-2018)

| Indicators | Varieties | | | | | |
|---|---|---|---|---|---|---|
| | Vikont | | | Mamluk | | |
| | 5.0 | 5.5 | 6.0 | 5.0 | 5.5 | 6.0 |
| Productivity of plants before harvesting, mln/ha | 336.0 | 382.0 | 430.0 | 330.0 | 376.0 | 428.0 |
| Weight of grains from one ear, g | 1.16 | 1.10 | 0.88 | 1.13 | 1.06 | 0.86 |
| Weight of 1,000 grains, g | 38.8 | 37.2 | 36.4 | 38.1 | 37.2 | 35.9 |
| Biological yield, t/ha | 3.89 | 4.20 | 3.78 | 3.75 | 3.94 | 3.67 |
| $MSD_{05}$ (t/ha) | | | 3.2 | | | 2.1 |

Comparison of the varieties by productivity and yield indicates that Vikont variety over performs Mamluk variety by 5-7 %. The weight of grains from one ear is 1.13 g in Mamluk variety and 1.16 g in the Viscount variety; the highest grain yield was obtained for Vikont variety 4.2 t/ha, while for Mamluk variety it was 3.94 t/ha.

The grain quality is equally important, especially if it is intended for processing into beer [6]. The plant stand during the grains formation influenced the starch and protein content in the barley grain.

The grain size, the weight of 1,000 grains, and the starch and protein content in the grain largely depend on the nutritional conditions of plants and their moisture supply. In turn, they depend on the number of plants per area unit [4].

It has been noted above that ears and grains are formed small in case of more bushy crops, the starch and protein content varies from the level of mineral nutrition and moisture provision. In case of sparse crops, the industrial development of plants usually occurs under more optimal conditions and the indicators of the productivity elements are higher than with bushy crops [14].

It must also be noted that the indicators of productivity elements and the yield of the summer barley varieties are different with the same seeding rate. This is due to the varietal peculiarity – when optimal conditions for the plants are created, they form almost potentially inherent elements of productivity and grain yield. The moisture supply of the soil during the growing season significantly influences the values of these indicators [11]. Moisture is required in sufficient volume, especially during the formation and development of generative organs. Size of the ear, its graininess, grain size, and yield depend on the level of plants moisture supply. Aside from the plant stand, the crop formation and its size depend on many other factors. This is also true for the grain quality, i.e. the suitability of grain for the brewing industry [15]. The results of analyses on the technological properties of grain are provided in Table 2.

**Table 2:**Technological properties of summer barley grain depending on the seeding rate

| Indicators | Varieties | | | | | |
|---|---|---|---|---|---|---|
| | Vikont | | | Mamluk | | |
| | 5.0 | 5.5 | 6.0 | 5.0 | 5.5 | 6.0 |
| 2016 | | | | | | |
| Weight of 1,000 grains, g | 38.2 | 37.0 | 36.2 | 37.8 | 37.0 | 35.6 |
| Natural weight, g/l | 626 | 617 | 613 | 620 | 615 | 612 |
| Starch content, % | 62.6 | 62.2 | 62.0 | 62.7 | 62.4 | 62.1 |
| Protein content, % | 11.8 | 11.9 | 12.1 | 11.7 | 11.9 | 12.0 |
| Extractivity, % | 75.9 | 75.4 | 75.0 | 76.1 | 75.7 | 75.2 |
| Hoodness, % | 8.9 | 8.9 | 8.9 | 8.8 | 8.8 | 8.9 |
| Grain color | straw yellow | | | | | |
| 2017 | | | | | | |
| Weight of 1,000 grains, g | 40.1 | 37.7 | 37.0 | 39.1 | 37.8 | 36.9 |
| Natural weight, g/l | 632 | 624 | 619 | 630 | 623 | 618 |
| Starch content, % | 64.5 | 64.0 | 63.6 | 64.4 | 64.1 | 63.5 |
| Protein content, % | 11.0 | 11.4 | 11.4 | 11.0 | 11.3 | 11.4 |
| Extractivity, % | 78.9 | 78.1 | 77.9 | 78.8 | 78.1 | 77.8 |
| Hoodness, % | 8.8 | 8.8 | 8.9 | 8.8 | 8.8 | 8.9 |
| Grain color | straw yellow | | | | | |
| 2018 | | | | | | |
| Weight of 1,000 grains, g | 38.1 | 36.2 | 36.0 | 37.4 | 36.8 | 35.2 |
| Natural weight, g/l | 630 | 622 | 613 | 619 | 614 | 612 |
| Starch content, % | 62.9 | 62.8 | 61.7 | 62.5 | 62.5 | 62.2 |
| Protein content, % | 11.0 | 11.5 | 11.9 | 11.6 | 12.0 | 12.1 |
| Extractivity, % | 75.6 | 74.8 | 74.2 | 76.4 | 75.9 | 75.5 |
| Hoodness, % | 8.9 | 8.9 | 9.0 | 8.9 | 8.9 | 8.9 |
| Grain color | straw yellow | | | | | |

The data in the table indicate that both the natural weight and the weight of 1,000 grains depend on the hydrothermal conditions during grain formation and ripening. The studies have indicated that the barley grain grows larger and more fulfilled with the more optimal moisture supply of plants, which is especially evident with the least plant stand.

Grain quality indicators in 2016 and 2018 differ from those of 2017. The weight of 1,000 grains in 2016 and 2018 was 38.2 g and 38.1 g, respectively, while in 2017 it was 40.1 (5.0 mln seeds/ha). Regardless of the climatic conditions, the indices of a plant decrease if the seeding rate per area unit is increased. For example, the weight of 1,000 grains was 40.1 g at a seeding rate of 5.0 mln seeds/ha (variety Vikont, 2017) but decreased to 37.0-37.7 g if the seeding rate had been increased to 5.5 and 6.0 mln seeds/ha.

The influence of external conditions on the technological performance of each variety is so significant that the same variety can be malting in one year and fodder in another. The protein content increased, and that of starch decreased in years with less precipitation and higher air temperatures [9]. Lower grain size is also characteristic of Mamluk variety. The weight of 1,000 grains of this variety ranges between 36 g and 38 g, although it can form grains with weight of 39 g or more in more favorable years.

The most important indicator of the technological properties of barley grain is its extractivity. It mainly depends on the starch content in the grain – the main component of the endosperm passing into the aqueous solution after hydrolysis [5].

The starch content and grain extractivity largely depend on growing conditions and varietal peculiarities. In the years of the study when plants were better supplied with moisture, the starch content was 2-2.5 % higher than in the years with insufficient provision of moisture. The starch content in grain was 64.4 % (5.0 mln/ha) in 2017, and 62.7-62.9 % in 2016 and 2018. The opposite is observed for the protein content: protein decreases if starch increases, and, conversely, protein increases if the starch content in grain decreases.

As for the impact the seeding rate has on the starch content in barley grains, a slight trend is observed for starch to decrease and protein to increase. When the seeding rate increases, the starch content in Vikont variety is higher than that of Mamluk variety [10].

As proved above, the use of barley with high content of extractive substances allows to obtain greater yield of beer from the same amount of raw materials. The results of the analysis indicate that the extractivity of Vikont variety was 78.9 % with a seeding rate of 5.0 mln/ha in 2017, which was quite suitable for brewing. It was 6-7 % better than other options.

The grain hoodness and color generally comply with the requirements of GOST 5060-86 "Malting barley. Technical conditions" [1].

It must be noted that according to the chemical composition and physical properties of the grain, multirow barley varieties form grains that meet the requirements of brewing under certain conditions, although two-row barley is more often used in the brewing industry.

## CONCLUSION

As such, the cultivation of multirow summer barley varieties typical of Vikont variety in the foothill area of the republic will allow to obtain grain yields up to four tons with high technological properties that meet the requirements of the brewing industry. As a result of the research, it has been established that the best barley grain quality for the brewing industry is achieved at a seeding rate of 5.0 mln viable seeds per hectare. They form grains of larger size, flattened, with starch content of more than 62 %, protein content between 11 and 12 %, and extractivity of about 80 %.

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