

қажеттігін көрсетеді және осы көрсеткіш бойынша баланстық сальдо мәндерін тұрақты бақылауды талап етеді.

Кілт сөздер: гумустың мазмұны, егістік, құнарлылық, бақылау.

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MONITORING OF ORGANIC SUBSTANCES IN ARABLE SOILS OF NORTHERN KAZAKHSTAN

Abstract

Soil fertility in Kazakhstan's main grain-growing regions is essential for successful agriculture, and its preservation is a top priority for farmers. Chernozem soils are prevalent in the northernmost part of the country, covering the entire North Kazakhstan region, most of the Kostanay region, and the northern regions of the Akmola region. All chernozem soils are fertile, but they are classified as low-moisture (less than 40 cm) with a content of organic matter of 6-8 % in the first two, and 4-6 % in the southern chernozems. The paper presents the results of research on the content of organic matter (humus) in the arable soil of the North Kazakhstan, Kostanay, and Akmol regions during the cultivation of field crops. The object of the study was the arable soil of agricultural formations. The method of determining the percentage of humus content is based on the oxidation of organic matter with a solution of potassium dichromate in sulfuric acid. On average, the humus content in the North Kazakhstan region was 4,6-5,5 %, in the Kostanay region it was 3,3-4,8 %, and in the Akmola region it was 3,2-4,5 %. In the current conditions of agricultural production, the humus balance in the region's arable soils remains negative, indicating a decrease in fertility and the need to replenish it through the application of organic fertilizers and the use of resource-saving agricultural practices for cultivating crops. This requires constant monitoring of the balance values for this indicator.

Key words: humus content, arable land, fertility, and monitoring.

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DEVELOPMENT AND IMPLEMENTATION OF INNOVATIVE AGRICULTURAL TECHNOLOGIES FOR CULTIVATION OF MELTING BARLEY TAKING INTO ACCOUNT THE SPECIFICITY OF SOIL AND CLIMATIC CONDITIONS OF ALMATY REGION TO INCREASE PRODUCTIVITY AND QUALITY OF RAW MATERIALS

Abstract

The increasing need to enhance the efficiency of brewing barley cultivation, a key crop for brewing and food industries, is critical amid climate change, unstable moisture, and soil resource depletion. This study scientifically evaluates optimal agronomic practices—specifically sowing dates and seeding rates—tailored to the soil and climatic conditions of the Balkhash district, Almaty region. Multi-year research on the brewing barley variety "Arna" assessed the impact of sowing timing and seeding density on plant growth, phenology, productivity, and grain quality. Results showed that early

sowing with a seeding rate of 5.0 million viable seeds per hectare fosters strong seedling establishment, optimal development, and high yields reaching 30.1 centners per hectare. Increasing seeding rates from 2 to 6 million seeds per hectare raised productive stem counts from 300 to 460 per m² but reduced productive tillering, indicating plant compensatory responses. Correlation analysis revealed a strong positive relationship between grain number per spike and spike productivity ($r = 0.977$) and a negative correlation between productive tillering and seeding rate ($r = -0.847$). Grain quality at the optimal seeding rate (5.0 million seeds/ha) was characterized by high test weight (up to 654 g/l), grain size (up to 85%), germination rate (up to 95%), husk content (~9.5%), protein (~11.6%), starch (up to 61.3%), and extractivity (up to 76.1%). Although increasing seeding rate to 6.0 million seeds/ha improved yield and thousand-kernel weight, it lowered protein content. These findings underscore the importance of a comprehensive, locally adapted approach to sowing dates and seeding rates to maximize yield and grain quality of "Arna" brewing barley. The recommended agronomic practices produce grain meeting GOST 5060-86 standards, supporting regional brewing industry development. The results provide valuable guidance for optimizing brewing barley cultivation technologies under regional conditions.

Key words: *malting barley, Arna variety, sowing dates, seeding rate, grain yield and quality, phenology, productive tillering.*

Introduction

Brewing barley is a vital agricultural crop used in beer production, where the quality of raw materials directly affects both the technological processes and the final product. In the current context of increasing demands for grain quality and production stability, the development and implementation of innovative agronomic technologies tailored to the specific soil and climatic conditions of individual regions have become essential. The Almaty region, characterized by a moderately continental climate with variable moisture levels and diverse soil types, imposes particular challenges on the selection of barley varieties and cultivation practices for brewing purposes.

In the Almaty region, it has been determined that the most suitable predecessors for cultivating brewing barley are row crops such as sugar beet, maize, potatoes, and fodder root crops, as well as winter cereals grown on fertilized fallow land. These crops are typically cultivated on well-prepared and fertilized soils, which helps reduce field weed infestation. The undersowing of perennial leguminous grasses before brewing barley is not recommended, since the presence of clover has been shown to increase the protein content in barley grain by 1–1.2% while decreasing starch content by 2–5%. When selecting the position of barley in crop rotation, it is important to recognize that having an appropriate predecessor alone does not guarantee a high yield of grain with the desired quality. Both yield and grain quality largely depend on the soil tillage system, including soil structure, bulk density, mechanical composition, phytosanitary condition, and the choice of predecessor. These factors justify the need for a differentiated approach to soil cultivation [1–4].

The primary soil cultivation system includes post-harvest stubble cultivation, plowing, or alternative methods of autumn tillage. When barley is grown after row crops, autumn plowing is performed immediately following their harvest. On fields with light to medium loamy soils, free of weeds and following crops such as potatoes, maize, and sugar beet, deep loosening can effectively replace autumn plowing. For barley cultivation after winter wheat, three soil treatment options are possible: first, removal of straw followed by stubble cultivation to a depth of 5–8 cm, treatment of root-sprouting weeds with moldboard harrows at 8–12 cm depth, and moldboard plowing with a subsoiler to 20–22 cm; second, chopping and incorporating straw using heavy disc harrows followed by plowing to the same depth; third, sowing post-harvest cover crops (such as white mustard, oilseed radish, winter rye, spring rapeseed, etc.) for green fodder and green manure, with autumn plowing after their removal. Incorporating straw into the soil increases organic matter content by 4–6 tons per hectare, which positively affects barley yield [5–9].

For sowing, regionally adapted or promising barley varieties with high yield potential, lodging resistance, and brewing-quality grain, suited to local soil and climatic conditions, are used. Among these, the two-row spring barley variety "Arna," belonging to the nutans type and bred for brewing

purposes, stands out. This variety is notable for its resistance to early spring frosts and drought tolerance, moderate susceptibility to common bunt, and low susceptibility to loose smut. It has been included in the State Register since 1997 [10–11].

Developed by individual selection from a hybrid population between K-26180 (Sweden) and Kharkovskaya 73 (Ukraine), "Arna" is an early-maturing variety with a growing period of 75–85 days, plant height of 78–87 cm, and productive tillering of 2.6–3.7 shoots per plant. Its high resistance to lodging, shattering, and pre-harvest sprouting ensures yield stability. The number of grains per spike ranges from 24 to 30, with an erect plant habit, narrow and long leaves without drooping, and a parallel-shaped spike of medium density with yellow coloration. The thousand-kernel weight reaches 50 g, test weight is 704.7 g/l, protein content does not exceed 12%, starch content ranges from 60 to 63%, and extractives amount to 76–81%. The average yield of the variety during three years of competitive trials was 63.1 centners per hectare [12–14].

The adoption of modern biotechnologies, including foliar treatments and the application of bio-organic fertilizers, shows promising potential for enhancing the productivity and resilience of barley in the Almaty region. Therefore, the scientific justification and practical implementation of innovative agronomic technologies that consider the region's specific soil and climatic conditions represent a crucial approach to ensuring the stable production of high-quality brewing barley in this area [15, 16].

The objective of this study is to scientifically determine the optimal sowing dates and seeding rates for the spring barley variety "Arna," intended for brewing purposes, under the natural and climatic conditions of the Balkhash district in the Almaty region. The research aims to identify the most effective agronomic parameters that ensure maximum productivity and high grain quality, tailored to the specific soil and hydrothermal conditions of the region.

Materials and Methods

Field experiments were conducted from 2021 to 2023 at the experimental site of LLP "AGRO-FIRMA OTES-A," located in the Bakanas settlement district of the Balkhash region, Almaty oblast. The study focused on the two-row spring barley variety "Arna," which is included in Kazakhstan's list of valuable brewing barley varieties and recommended for cultivation in the Almaty region.

Agrometeorological conditions during the experimental years were relatively favorable in 2021, whereas in 2022 and 2023, plant growth and development occurred under comparatively dry conditions, especially during the latter half of the growing season.

Experimental Design

Experiment 1. Effect of Sowing Dates on Yield and Grain Quality:

1. First sowing date — at the onset of soil physical maturity.
2. Second sowing date — 5 days after the first (control).
3. Third sowing date — 10 days after the first.
4. Fourth sowing date — 15 days after the first.

Experiment 2. Effect of Seeding Rates on Yield and Grain Quality:

1. Seeding rate of 4.0 million viable seeds per hectare.
2. Seeding rate of 4.5 million viable seeds per hectare (control).
3. Seeding rate of 5.0 million viable seeds per hectare.
4. Seeding rate of 5.5 million viable seeds per hectare.
5. Seeding rate of 6.0 million viable seeds per hectare.

Treatments were arranged in a sequential layout. The plot size for each variant was 50 m². The experiments were conducted in four replications. Sowing was performed using an SN-16 seed drill, and harvesting was carried out with a Sampo-500 grain combine harvester.

Results and discussion

During the conducted research, soil preparation before sowing involved a comprehensive set of agronomic practices, including stubble cultivation, deep autumn plowing, snow retention, harrowing, and cultivation. The composition and sequence of these preparatory operations varied depending on the soil's physico-chemical properties, climatic conditions, preceding crops, and other agroecological factors. Brewing barley is classified as an early-maturing cereal, which necessitates early sowing.

Delays in sowing dates resulted in a yield reduction ranging from 10% to 40%, whereas early sowing promoted the development of strong seedlings and larger grain size.

Sowing operations adhered to established standards, with an average seeding rate of approximately 5 million viable seeds per hectare, taking into account the varietal characteristics of "Arna" and specific agronomic conditions. Seed placement depth varied according to soil type: 6 cm on sandy loam soils and 3–4 cm on moist and clayey soils. The choice of sowing method depended on the seeding rate: for rates exceeding 5 million seeds per hectare, a narrow-row method with 7.5 cm spacing between rows was used; for lower rates, a regular row method with 15 cm spacing was applied. Heading began on the 41st day after emergence, with full development of anthers and pistils with stigmas. Flowering, a critical developmental phase, started roughly three days after heading and was marked by the cessation of growth in vegetative organs and the root system. Moderate temperatures are essential for successful completion of the tillering phase. In the study years, elevated temperatures during tillering were recorded in 2021 for the fourth sowing date (+20.0 °C) and in 2023 for the third sowing date (+23.1 °C), while average temperatures for other sowing dates ranged between 16–17 °C. Sowing conducted in the second and third decades of May under higher temperatures showed a significant shortening of the period from emergence to heading. For early sowing dates, this period was longer, lasting 23–32 days. During the jointing phase, reproductive organs were formed, and plants became especially sensitive to moisture deficits and light conditions.

Overall, during the period from sowing to full maturity, early sowings accumulated an average temperature sum of 1559.4 °C with an average temperature of 17.9 °C; second sowings (7 days later) accumulated 1613.4 °C at 19.4 °C; and late sowings (24 days later) accumulated 1594.7 °C at 20.2 °C. The optimal temperature values (1461.9 °C and 17.4 °C) were closest to those observed for early sowing dates. The study also revealed that delaying sowing by 7 and 14 days corresponded with increases in average and maximum air temperatures during the sowing-to-emergence period by 1.5–2.5 °C and 2.5–3.2 °C, respectively. This trend persisted through subsequent developmental phases: emergence to tillering, tillering to heading, and heading to milk maturity (Table 1).

Table 1 –The influence of sowing time and seed ingrateon the growth of malting barley, 2021-2023.

Seedingrates, million/ha	Shoots tillering	Tillering Stem elongation (jointing) Flowering	Heading Flowering	Milkstage	Waxmaturity (Waxstage)	Full maturity
First sowing date (at the onset of soil physical maturity)						
2,0	6.05	13.05	27.05	21.06	15.07	10.08
3,0 (control))	6.05	13.05	27.05	21.06	15.07	10.08
4,0	6.05	13.05	27.05	21.06	15.07	10.08
5,0	6.05	13.05	27.05	18.06	13.07	08.08
6,0	6.05	13.05	27.05	21.06	15.07	09.08
Second sowing date (5 days after the first date, control)						
2,0	22.04	5.05	16.05	7.06	30.07	11.08
3,0 (control)	21.04	2.05	16.05	7.06	30.07	07,08
4,0	21.04	2.05	16.05	7.06	30.07	07,08
5,0	20.04	1.05	14.05	5.06	27.07	06,08
6,0	22.04	5.05	14.05	6.06	30.07	10,08
Third sowing date (10 days after the first date)						
2,0	30.04	2.05	16.05	8.06	2 .07	17.08
3,0 (control)	30.04	2.05	16.05	8.06	2 .07	17.08
4,0	30.04	2.05	16.05	8.06	2 .07	17.08
5,0	30.04	2.05	14.05	6.06	1 .07	13.08
6,0	30.04	2.05	15.05	8.06	2.07	15.08
Fourth sowing date (15 days after the first date)						
2,0	30.04	18.05	22.06	14.07	8.08	25.08
3,0 (control)	28.04	18.05	22.06.	14.07	8.08	25.08

4,0	29.04	17.05	21.06	12.07	6.08	25.08
5,0	29.04	17.05	21.06	12.07	6.08	25.08
6,0	30.04	18.05	22.06	14.07	8.08	25.08

Adverse growing conditions significantly affect plant development, leading to delays in ontogenetic progress and insufficient formation of aboveground vegetative biomass. Under unstable moisture regimes, the timing of phenological phases and the duration of intervals between them largely depend on the thermal conditions during the growing season and soil moisture levels, while the impact of agronomic practices plays a comparatively minor role. An analysis of yield components in barley varieties, considering sowing dates and seeding rates, revealed that timely sowing combined with an optimal seeding rate positively influences key yield factors: tillering, stem density, number of grains per spike, and thousand-kernel weight. Spike productivity is determined by both the thousand-kernel weight and the grain count per spike. Correlation analysis calculated partial correlation coefficients between grain number per spike and spike productivity ($r = 0.977 \pm 0.090$), thousand-kernel weight ($r = 0.722 \pm 0.298$), productive tillering ($r = 0.793 \pm 0.262$), as well as the number of productive stems, where a negative correlation was observed ($r = -0.872 \pm 0.240$). Structural analysis of sheaves showed that increasing the seeding rate from 2 to 6 million viable seeds per hectare raised the number of productive plants per unit area from 300 to 460. At the same time, productive tillering tended to decrease (Table 2), indicating the presence of compensatory mechanisms in yield formation as plant density changes. Therefore, optimizing sowing dates and seeding rates is a crucial factor in balancing the number of productive plants with their individual productivity, ultimately affecting the overall yield and grain quality of brewing barley.

Table2 – Elements of the productivity structure of the Arna variety for 2021-2023.

Seeding rates, million per 1 ha	Number of productive stems, pcs.	Productivetillering	Number of grains per spike, pcs	Grain weight per spike, g	Thousand-kernelweight, g
First sowing date (at the onset of soil physical maturity)					
2,0	179,7	2,53	40,0	2,11	65,7
3,0 (control)	222,7	2,27	30,3	2,06	65,0
4,0	381,3	3,18	38,3	1,99	64,0
5,0	413,7	2,08	47,7	1,93	63,4
6,0	541,7	2,02	36,3	1,84	61,5
Second sowing date (5 days after the first date, control)					
2,0	121,0	1,65	30,0	1,11	55,7
3,0 (control)	168,7	1,66	19,3	1,06	55,0
4,0	192,7	1,18	18,3	0,99	54,0
5,5	194,0	1,01	17,7	0,93	53,4
6,0	126,3	1,04	16,3	0,84	51,5
Third sowing date (10 days after the first date)					
2,0	111,0	1,60	29,0	1,11	45,7
3,0 (control)	158,7	1,62	29,3	1,06	45,0
4,0	152,7	1,10	16,3	0,79	44,0
5,0	154,0	1,00	15,7	0,83	43,4
6,0	116,3	1,04	16,3	0,74	41,5
Fourth sowing date (15 days after the first date)					
2,0	221,0	1,85	19,7	1,03	42,8
3,0 (control)	268,7	1,56	18,7	1,00	43,7
4,0	292,7	1,28	18,7	0,96	41,2
5,0	294,0	1,11	16,7	0,86	41,7
6,0	326,3	1,04	15,5	0,79	40,9

Plant growth and development under different sowing dates occurred under varying conditions, which significantly influenced the growth dynamics of spring barley. The most favorable hydrothermal conditions for vegetation were observed with early sowing, ensuring adequate moisture availability during the tillering to heading phases. Earlier sowing extended the duration of initial

growth stages and the entire growing period, whereas delayed sowing accelerated plant development. For instance, the vegetative period at the first sowing date lasted approximately 80 days.

Conversely, at the second sowing date (5 days after the first, control) with seeding rates of 5.0 and 6.0 million seeds per hectare, a slight decline in germination energy and deterioration in grain uniformity were noted, despite a minor increase in germination capacity (Table 3).

Table 3 – Average indicators of brewing properties of barley grain in experiments in 2021–2023.

Seeding rates, million per 1 ha	Husk content, %	Grain size, %	Alignment, %			Fine grains, % 22 mm	Germination energy, %	Germination ability, %	Extractivity, % dry weight
			28 mm	25 mm	22 mm				
First sowing date (at the onset of soil physical maturity)									
2,0	7,8	98,3	86,9	11,4	1,3	0,4	97,3	98,5	80,3
3,0 (control)	7,8	97,4	84,5	12,9	2,0	0,4	98,3	98,7	80,6
4,0	8,3	98,9	87,6	11,4	0,9	0,2	96,1	98,3	80,4
5,0	8,4	96,8	75,6	21,2	2,4	0,8	96,5	98,7	81,1
6,0	8,0	98,4	87,0	11,4	1,4	0,2	96,9	99,3	80,1
Second sowing date (5 days after the first date, control)									
2,0	6,5	78,3	66,9	9,4	1,0	0,1	77,3	78,5	69,3
3,0 (control)	6,4	77,4	64,5	10,9	0,9	0,2	78,3	78,7	67,6
4,0	7,2	78,9	67,6	9,4	0,7	0,1	76,1	78,3	68,4
5,0	7,3	76,8	55,6	19,2	1,3	0,5	76,5	78,7	61,1
6,0	6,9	78,4	67,0	9,4	0,3	0,1	86,9	79,3	60,1
Third sowing date (10 days after the first date)									
2,0	7,4	95,8	72,6	19,2	1,4	0,7	90,5	94,7	89,1
3,0 (control)	7,0	94,3	82,2	10,1	1,1	0,4	91,7	95,1	75,4
4,0	8,4	96,8	75,6	21,2	2,4	0,8	96,5	98,7	81,1
5,0	8,0	98,3	87,2	11,1	1,2	0,5	97,7	98,1	79,4
6,0	8,0	97,8	84,8	13,1	1,8	0,4	97,5	98,9	79,0
Fourth sowing date (15 days after the first date)									
2,0	6,8	88,3	76,9	10,4	1,2	0,3	87,3	88,5	70,3
3,0 (control)	6,8	87,4	74,5	11,9	1,0	0,3	88,3	88,7	70,6
4,0	7,3	88,9	77,6	10,4	0,8	0,1	86,1	88,3	70,4
5,0	7,4	86,8	65,6	20,2	2,3	0,7	86,5	88,7	71,1
6,0	7,0	88,4	77,0	10,4	1,3	0,1	86,9	89,3	70,1

Under the humid hydrothermal conditions of 2022 (hydrothermal coefficient, HTC = 2.3), the reduction in test weight and increase in grain protein content did not adversely affect the malting qualities, as these parameters remained within optimal ranges. In contrast, during the drier seasons of 2021 and 2023 (HTC = 1.0–1.3), at seeding rates of 3.0–4.0 million seeds per hectare, grain protein content exceeded normative values, reaching 13–14% at a seeding rate of 6.0 million seeds per hectare. In the 2021 and 2023 trials, barley yield increased by 10–20%, accompanied by improvements in thousand-kernel weight, germination energy, and viability, while protein content decreased to within the normative threshold. Increasing the seeding rate to 6.0 million seeds per hectare at the first sowing date (soil physical maturity) enhanced productivity by 17–21%, improved test weight, germination energy, and thousand-kernel weight, but reduced protein concentration.

Early sowing (at soil physical maturity) contributed to enhancements in grain size, germination energy, viability, and uniformity. Stem density, regulated by seeding rate, influenced malting quality: increasing the seeding rate from 4.0 to 5.0 million seeds per hectare elevated test weight from 647 to 654 g/l, whereas further densification to 6.0 million seeds per hectare reduced test weight to 648 g/l. Grain size decreased from 86% to 78% as seeding rates increased from 4.0 to 6.0 million seeds per

hectare, with the highest grain size percentages (84–89%) recorded in 2021. Growing conditions affected grain germination capacity, which averaged 85–95% over three years, showing a tendency to decline with increasing plant density: 85% at 6.0 million seeds per hectare versus 95% at 5.0 million seeds per hectare. Conversely, grain husk content exhibited an opposite trend, being higher at seeding rates of 5.5 and 6.0 million seeds per hectare (averaging 10.2% and 10.6%, respectively) compared to 4.0–5.0 million seeds per hectare (9.6–9.7%). The biochemical composition of the grain was largely determined by varietal characteristics but also varied according to environmental conditions. Protein content at seeding rates of 4.5 and 5.0 million seeds per hectare complied with GOST standards (averaging 11.9% and 11.6%, respectively), whereas at 4.0, 5.5, and 6.0 million seeds per hectare, protein levels were elevated (12.2–13.1%) (Table 4).

Table 4 – Brewing quality of barley grain depending on seeding rates averaged over 2021–2023

Indicators	Seeding rates, million seeds per hectare				
	2,0	3 (control)	4,0	5,0	6,0
«Arna» variety					
Test weight of grain, g/l	647	649	654	648	648
Grainsize, %	86	86	85	78	78
Germination capacity, %	92	91	95	85	85
Husk content, %	9,6	9,7	9,5	10,5	10,5
Protein content, %	12,2	11,9	14,6	18,1	13,1
Starch content, %	60,6	60,9	61,3	59,8	59,8
Extract content, %	75,7	75,9	76,1	74,1	74,1

Starch content increased with the rise in seeding density from 4.0 to 5.0 million seeds per hectare, averaging 60.6–61.3% over three years, whereas further densification to 6.0 million seeds per hectare led to a decrease to 59.8%. A similar trend was observed for grain extract content, which reached its maximum value (76.1%) at the seeding rate of 5.0 million seeds per hectare. No significant effect of sowing dates on husk content was detected; however, a general tendency toward its reduction was noted at the optimal sowing time. Varietal differences were pronounced, with the “Arna” variety exhibiting the most favorable husk content values.

Conclusions

The study revealed significant differences in the initial growth rates among the barley varieties examined. Although emergence occurred simultaneously, the spring barley variety “Arna” exhibited distinctive developmental characteristics. Under favorable moisture conditions (2022), these differences were less pronounced; however, they remained substantial on average throughout the entire study period. During the heading phase, “Arna” averaged 4.5 productive stems and nodal roots per plant over three years. Exhibiting high lodging resistance, plants of this variety were taller by approximately 10 cm, had improved leafiness, and deeper placement of the tillering node, which contributed to enhanced drought tolerance. Seeding rate had a significant impact on the malting quality of “Arna” grain. Optimal values for test weight (654 g/l), grain size (85%), germination capacity (95%), husk content (9.5%), protein content (11.6%), starch content (61.3%), and extract content (76.1%) were achieved at a seeding rate of 5.0 million seeds per hectare. Recommended agronomic practices, including early sowing and a seeding rate of 5.0 million seeds per hectare, ensure a grain yield of 30.1 centners per hectare, meeting the requirements of GOST 5060-86 (“Brewing Barley. Technical Specifications”), there by promoting high economic efficiency in production.

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АЛМАТЫ ОБЛЫСЫНЫҢ ТОПЫРАҚ-КЛИМАТТЫҚ ЖАҒДАЙЛАРЫНДА ШИКІЗАТТЫҢ ӨНІМДІЛІГІ МЕН САПАСЫН АРТТЫРУ МАҚСАТЫНДА СЫРА АРПАСЫНЫҢ ӨСІРУДІҢ ИННОВАЦИЯЛЫҚ АГРОТЕХНОЛОГИЯЛАРЫН ӘЗІРЛЕУ ЖӘНЕ ЕНГІЗУ

Аңдатпа

Сыралық арпаны өсіру тиімділігін арттыру қажеттілігі өсіп келеді, бұл да пивоварлық және тамақ өнеркәсібі үшін маңызды ауыл шаруашылығы дақылы болып табылады. Климаттың өзгеруі, ылғалдың тұрақсыздығы және топырақ-агрономиялық ресурстардың таусылуы жағдайында аймақтың нақты топырақ-климаттық жағдайларына бейімделген егіс мерзімдері мен егу нормалары сияқты оңтайлы агротехникалық тәсілдерді ғылыми негіздеу ерекше маңызды болып отыр. Мақалада Алматы облысының Балқаш ауданының табиғи-климаттық жағдайларында «Арна» сұрыпты пивоварлық арпаның егіс мерзімдері мен егу нормаларының өсуі, дамуы, фенологиялық ерекшеліктері, өнімділігі және дән сапасына кешенді көпжылдық зерттеулер нәтижелері ұсынылған. Зерттеу барысында гектарына 5,0 млн өскін дән нормасымен ерте егу мерзімі мықты өскіндердің қалыптасуына, өсімдіктердің оңтайлы дамуына және жоғары өнімділікке – 30,1 ц/га дейін жетуге ықпал ететіні анықталды. Өнім құрылымының талдауы бойынша, егу нормасының 2 млн-нан 6 млн-ға дейін өсуі өнімді сабағының санын 300-ден 460 шт./м²-ге арттырғанымен, өнімді бұталылық төмендейтінін көрсетті, бұл өсімдіктердің өтемдік механизмдерін білдіреді. Корреляциялық талдау құрақтағы дән саны мен құрақ өнімділігі арасындағы жоғары байланысты ($r = 0,977$), сондай-ақ өнімді бұталылық пен егу нормасы арасындағы кері байланысты ($r = -0,847$) растады. «Арна» сұрыпты дән сапасы натура көрсеткіштерімен (654 г/л дейін), іріктілігімен (85% дейін), өну қабілетімен (95% дейін), пленчаттылығымен (шамамен 9,5%), ақуыз мөлшерімен (шамамен 11,6%), крахмал мөлшерімен (61,3% дейін) және экстрактивтілігімен (76,1% дейін) сипатталды, бұл оптималды 5,0 млн дән нормасында байқалды. Сонымен қатар, егу нормасын 6,0 млн дәнге дейін арттыру өнімділік пен 1000 дән массасының өсуіне ықпал еткенімен, ақуыз мөлшерін төмендетті. Аталған деректер жергілікті топырақ-климаттық жағдайларға бейімделген егіс мерзімдері мен егу нормаларын кешенді түрде таңдау қажеттігін көрсетеді, бұл «Арна» сұрыпты пивоварлық арпаның жоғары өнімділігі мен сапасын қамтамасыз етеді. Ұсынылған агротехникалық шаралар ГОСТ 5060-86 талаптарына сәйкес келетін дән алуға мүмкіндік береді, бұл өңірдің пивоварлық саласының дамуы үшін маңызды. Алынған нәтижелер аймақ жағдайында пивоварлық арпаны өсіру технологияларын оңтайландыруға ұсынылады.

Кілт сөздер: Сыралық арпа, «Арна» сұрыпты, егу мерзімдері, егу нормасы, өнімділік пен дән сапасы, фенология, өнімділік.

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РАЗРАБОТКА И ВНЕДРЕНИЕ ИННОВАЦИОННЫХ АГРОТЕХНОЛОГИЙ ВОЗДЕЛЫВАНИЯ ПИВОВАРЕННОГО ЯЧМЕНЯ С УЧЁТОМ СПЕЦИФИКИ ПОЧВЕННО-КЛИМАТИЧЕСКИХ УСЛОВИЙ АЛМАТИНСКОЙ ОБЛАСТИ ДЛЯ ПОВЫШЕНИЯ ПРОДУКТИВНОСТИ И КАЧЕСТВА СЫРЬЯ

Аннотация

Растущая потребность в повышении эффективности возделывания пивоваренного ячменя, которая является важной сельскохозяйственной культурой для пивоваренной и пищевой промышленности. В современных условиях изменения климата, неустойчивого увлажнения и истощения почвенно-агрономических ресурсов особенно важным становится

научное обоснование оптимальных агротехнических приёмов, таких как сроки посева и нормы высева, адаптированных к конкретным почвенно-климатическим условиям региона. В статье представлены результаты комплексных многолетних исследований влияния сроков посева и норм высева семян на рост, развитие, фенологические особенности, продуктивность и качество зерна пивоваренного ячменя сорта «Арна» в природно-климатических условиях Балхашского района Алматинской области. Установлено, что ранний срок посева при норме высева 5,0 млн всхожих семян на гектар способствует формированию крепких всходов, оптимальному развитию растений и достижению высокой урожайности — до 30,1 ц/га. Структурный анализ урожая выявил, что увеличение нормы высева с 2 до 6 млн семян/га приводит к росту количества продуктивных стеблей с 300 до 460 шт./м², однако продуктивная кустистость снижается, что отражает компенсаторные механизмы растений. Корреляционный анализ подтвердил высокую связь между числом зерен в колосе и продуктивностью колоса ($r = 0,977$), а также обратную зависимость продуктивной кустистости от нормы высева ($r = -0,847$). Качество зерна сорта «Арна» характеризовалось высокими показателями натурности (до 654 г/л), крупности (до 85%), прорастания (до 95%), пленчатости (около 9,5%), содержания белка (около 11,6%), крахмала (до 61,3%) и экстрактивности (до 76,1%) при оптимальной норме высева 5,0 млн шт./га. При этом увеличение нормы высева до 6,0 млн шт./га способствовало росту урожайности и массы 1000 зерен, но снижало содержание белка. Полученные данные свидетельствуют о необходимости комплексного подхода к выбору сроков посева и норм высева, адаптированного к местным почвенно-климатическим условиям, для обеспечения высокой урожайности и качества пивоваренного ячменя сорта «Арна». Рекомендованная агротехника позволяет получать зерно, соответствующее требованиям ГОСТ 5060-86, что имеет важное значение для развития пивоваренной отрасли региона. Полученные данные могут быть рекомендованы для оптимизации технологий возделывания пивоваренного ячменя в условиях региона.

Ключевые слова: Пивоваренный ячмень, сорт «Арна», сроки посева, норма высева, урожайность и качество зерна, фенология, продуктивная кустистость.

Authors' contributions

M.G.: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; ; Roles/Writing – original draft; and Writing – review & editing; **R.B.:** Conceptualization; Data curation; Formal analysis; Investigation; Methodology; ; Roles/Writing – original draft; and Writing – review & editing; **I.A.:** Resources; Software; Supervision; Validation; Visualization; Roles/Writing – original draft; and Writing – review & editing; **I.E.:** Resources; Software; Supervision; Validation; Visualization; Roles/Writing – original draft; and Writing – review & editing; **Zh.Zh.:** Resources; Software; Supervision; Validation; Visualization; Roles/Writing – original draft; and Writing – review & editing; **K.E.A.:** Resources; Software; Supervision; Validation; Visualization; Roles/Writing – original draft; and Writing – review & editing.