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Influence of sowing time and rates on the productivity of spring barley varieties under the conditions of South-East of Kazakhstan

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Abstract

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The study presents the results of growing barley of the Zhuldyz variety under the conditions of the Almaty region at seeding rates of 4, 5, 6, and 7 million viable seeds per hectare. Early sowing extends the barley vegetation period and reduces the dependence of grain yield on atmospheric moisture. At the optimal sowing time (the second ten days of May) in the fields of LLC "AGRO-FIRM OTES-A" located in the Balkhash district of the Almaty region, grain yield is primarily determined by moisture reserves in the meter-deep soil layer and the temperature and moisture conditions during the first half of the growing season. Hydrothermal conditions during the growing season have a greater impact on grain yield than sowing dates and seeding rates. Under low-humidity conditions, barley should be sown as early as possible, and the seeding rate for a fallow predecessor should be reduced by 30–35% of the standard. Lowering the seeding rate minimizes competition between plants, allowing for the full development of the varietal potential of two-row barley. Due to the increased productive tillering of the Zhuldyz barley variety, an average over four years shows the formation of a dense, productive stem, ensuring a grain yield of 4,7 t/ha with early sowing and 5,0 t/ha with the optimal sowing time for the region. Our study indicates that modern barley varieties, when grown under favorable agricultural conditions, should be sown at a reduced rate.

Keywords: sowing dates; seeding rate; vegetation period; yield fluctuations

Introduction

Barley (Hordeum vulgare L.) is one of the most important cereal crops worldwide, valued for its versatility in food, feed, and brewing industries. Its productivity depends on various agronomic factors, including sowing dates, seeding rates, and environmental conditions. Optimizing these factors is essential to maximize yield and ensure economic efficiency in barley production. The choice of sowing date significantly influences barley growth, as early sowing can extend the vegetation period and reduce dependency on atmospheric precipitation. Additionally, seeding rate adjustments help regulate plant density, minimizing competition and promoting the full realization of the crop's genetic potential. This study aims to assess the impact of different sowing dates and seeding rates on the productivity of the Zhuldyz barley variety under the specific agro-climatic conditions of LLC "AGRO-FIRM OTES-A", located in the Balkhash district of the Almaty region. The findings will contribute to the development of optimal barley cultivation strategies, ensuring stable yields and economic viability. Barley is a key grain crop widely used in feed production, the food industry, and other sectors (Lapina et al., 2015, Surin et al., 2017, Puzyreva, 2013). In Kazakhstan, the barley cultivation area reached

2 million 344,5 hectares in 2022, reflecting a 9% increase compared to 2021 (2 million 157,4 hectares). This expansion highlights the growing importance of barley in the country's agricultural sector. In the Almaty region, barley is one of the leading grain crops, with a sown area of 81,2 thousand hectares. However, total grain yield varies significantly, primarily due to weather conditions during the growing season. Barley grain produced in the Almaty region is used not only as fodder but also for the brewing industry (approximately 5,000 tons in recent years), with part of the crop processed into cereals (Postnikov, 2018, Puzyreva, 2013). However, a major constraint on barley processing in the region is the instability of quality indicators, which are significantly affected by local soil and climatic conditions (Sabitova, A. et al., 2024). Both domestic and foreign researchers have noted that barley yield and grain quality depend on soil and climatic conditions (Perepichay, 2017), varietal potential (Ashaeva and Koshishov 2017), predecessor crops (Rustem et al., 2024), mineral fertilizers (Baimuratov et al., 2024,) and other factors.

Under these conditions, the recommended seeding rate varies:

3,5–4,5 million viable grains per hectare in certain regions.

4,5–5,0 million viable grains per hectare under different conditions.

In the Almaty region, the recommended seeding rate for grain production is 5,0–6,5 mil- lion viable seeds per hectare.

For zoned two-row barley varieties with a thousand grain weight exceeding 50–55 g, the physical seeding rate is 330–370 kg/ha (Tikhonov, 2007, Koshishova, 2016). However, this often results in an inefficient overuse of seed material. With early sowing, the barley growing season is extended, reducing the harvest's dependence on precipitation. Over the years, hydrothermal conditions during the growing season have had a greater impact on grain yield than sowing dates and seeding rates (Lamazhap, R. R. & Lipshin, A. G. 2016).

Material and Methods

The research was conducted through field experiments on barley crops at LLC "AGRO-FIRM OTES-A", located in the southern zone of the Balkhash district, Almaty region. The object of the research was the zoned mid-season barley variety Zhuldyz, which is recognized as the standard for barley variety testing in the Almaty region. Barley was grown at different sowing times: early sowing (late April – early May) and the optimal sowing period for the given agroclimatic zone (mid-May). The sowing dates differed by 12–15 days, depending on the year's weather conditions and the feasibility of conducting field experiments. The sowing dates varied each year depending on spring fieldwork conditions and the soil's physical readiness for sowing. The study of seeding rate influence, considering economic feasibility, was conducted according to the following scheme:

4 million viable seeds per hectare

5 million viable seeds per hectare

6 million viable seeds per hectare

7 million viable seeds per hectare

The cultivation technology is generally accepted for this zone. The plot area is 50 m², with an accounting area of 25 m². The plots are arranged sequentially. When setting up field experiments, the recommendations outlined in the Gosvartnet methodology were followed.

Results and Discussion

The results of phenological observations at a standard seeding rate are presented. It has been established that, depending on the year's conditions and different sowing dates, the length of the barley growing season varies. Moreover,

Table 1. Dates of the onset of the main phases of barley development during the research years

Year	Sowing	Shoots	The beginning of tillering	Bloom	Milk ripeness	Wax ripeness	Full ripeness	Harvesting
Early sowing date								
2020	28.04	12.05	24.05.	27.06	11.07	01.08	12.08	13.08
2021	28.04	13.05	01.06	24.06	05.07	29.07	13.08	13.08
2022	06.05	19.05	05.06	20.06	15.07	08.08	16.08.	16.08
2023	02.05	17.05	04.06	01.07	14.07	14.08	20.08	20.08
Optimal sowing times								
2020	13.05	24.05	10.06	03.07.	18.07	07.08	17.08	21.08
2021	13.05	21.05	10.06	01.07	18.07	05.08	13.08	15.08
2022	21.05	30.05	08.06	05.07	20.07	15.08	27.08	24.08
2023	17.05	29.05	12.06	05.07	29.07	01.09	08.09	08.09

Source: Authors' own elaboration

interphase periods are more influenced by hydrothermal conditions, which, in turn, affect the yield. The harvest outcome depends on the moisture conditions under which the main elements of the crop structure were formed (Table 1).

Changing the seeding rate-both increasing it to 7 million (ha and reducing it to 4 or 5 million) ha-led to a slight extension of the overall growing season. In the first case, this was due to the suppression of plants caused by increased competition. In the second case, the extension resulted from higher productive tillering. However, the shift in the duration of individual interphase periods of barley, starting from the flowering phase, ranges from 1 to 3 days and ultimately affects the overall length of the growing season (Table 2).

For assessment of the heat and moisture supply conditions under atmospheric influence, the hydrothermal coefficient was calculated, considering the phenology of barley development phases based on the main growth stages (Table 3).

The hydrothermal coefficient is the ratio between total precipitation during a given crop development period and the sum of temperatures (in degrees Celsius) divided by 10. A hydrothermal coefficient above 1,6 during the growing season indicates excessively humid conditions, while values between 1,6 and 1,3 correspond to moderately humid conditions. A coefficient in the range of 1,3–1,0 indicates insufficient moisture, while values between 1,0 and 0,7 correspond to dry conditions. Shifts in the calendar dates of phenological development phases-due to sowing dates and varying seeding rates-result in changes in the hydrothermal coefficient for a specific interphase period, as observed in experimental variations. At the optimal sowing time in most years of the study, the growing season was 4–5 days shorter than with early sowing. This was due to more favorable temperature conditions, particularly during the tillering-to-flowering period. In 2023, prolonged rainy weather in August significantly delayed the calendar dates for barley ripening and harvesting. When sowing in the second ten-day period of May (the optimal sowing time) and with higher air temperatures in the first half of the growing season, the length of the growing season is reduced. In 2023, excessive moisture in the second half of the growing season (GTC 1,91 and 1,61, respectively) led to an extension of the period from germination to full maturity. Calculations show that the GTC varies depending on annual conditions due to changing weather patterns during the growing season. In general, during the growing season, heat and moisture supply conditions are favorable. In most years, the GTC ranges from 1,3 to 1,6. However, in the 2020 growing season, waterlogging was observed throughout the entire period of barley growth and development. The likelihood of barley plants developing under conditions of insufficient atmospheric moisture is observed at the optimal sowing time for LLC "AGROFIRM OTES-A", (the second ten-day period of May). Thus, in 2022 and 2023, during the first half of the barley growing season, the GTC was 0,95 and 0,92 respectively, indicating an insufficient amount of precipitation. This, in turn, likely affected crop productivity (Table 4).

Table 3. Hydrothermal conditions for the main phases of barley development depending on sowing dates

Year of observations	Shoots-flowering	Flowering – full ripeness	Seedlings – full ripeness
Early sowing date			
2020 year	1,75	1,88	1,84
2021 year	1,51	1,50	1,48
2022 year	1,68	1,13	1,27
2023 year	1,30	1,91	1,65
Optimal sowing times			
2020 year	3,24	1,14	1,92
2021 year	1,61	1,44	1,50
2022 year	0,95	1,63	1,37
2023 year	0,92	1,68	1,49

Source: Authors' own elaboration

Table 2. Length of the growing season at different sowing dates and seeding rates during the research years (days)

Option	Research Year				
	2020 year	2021 year	2022 year	2023 year	average
Early sowing date					
4 million /ha	83	79	83	88	83
5 million /ha	83	79	82	87	83
6 million/ha (control)	82	78	82	87	82
7 million /ha	81	78	82	88	82
Optimal sowing times					
4 million /ha	79	78	78	95	83
5 million /ha	77	78	78	96	82
6 million/ha (control)	76	77	78	94	81
7 million /ha	78	77	77	95	81

Source: Authors' own elaboration

Table 4. Barley grain yield at different sowing dates and seeding rates, t/ha

Option	A year of research				
	2020 year	2021 year	2022 year	2023 year	average
Early sowing date					
4 million /ha	5,56	3,92	4,71	4,67	4,72
5 million /ha	5,22	4,94	4,14	4,88	4,80
6 million/ha (control)	5,15	4,68	4,33	4,77	4,73
7 million /ha	5,45	4,35	3,93	4,69	4,61
Average	5,35	4,47	4,28	4,75	4,71
Optimal sowing times					
4 million /ha	5,77	5,58	3,30	5,35	5,00
5 million /ha	5,78	4,95	3,16	5,48	4,85
6 million/ha (control)	5,99	4,92	3,26	5,19	4,84
7 million /ha	5,92	5,16	3,32	5,31	4,93
Average	5,87	5,15	3,26	5,33	4,90
NSR_{05} t/ha	0,03	0,03	0,02	0,04	

Source: Authors' own elaboration

Relatively high moisture supply of LLC "AGRO-FIRM OTES-A", the Zhuldyz variety provided a grain yield of 3,26 to 5,99 t/ha. In our opinion, the maximum yield in 2020 is due to the fact that in the first half of the growing season (before flowering), the plants developed with excess atmospheric moisture and high moisture reserves in the meter-thick layer under the crops. The high yield of 2023 is ensured by high reserves of soil moisture and good heat supply during the growing season. Thus, in the years of observations, the minimum amount of moisture in the meter-thick soil layer by the time of tillering of grain crops was in 2022 (one and a half to two times less than in other years). During the tillering period, the elements of the crop are laid down (productive tillering, the number of grains in the ear), therefore, a lack of moisture during this period negatively affects the productivity of barley, especially at the optimal sowing time, when part of the soil moisture evaporates unproductively. Delay in sowing in 2022 against the background of relatively low moisture reserves in the meter-thick layer (116 mm at the time of tillering of the crop) led to a sharp decrease in yield at the optimal sowing time. The critical period for moisture supply for barley is the tillering-booting phase, in addition, for this crop, the primary roots penetrate deep into the subsoil horizons and provide the plants with moisture. In 2022, with a first-half GTC of 0.95 and moisture reserves during the tillering period of less than 120 mm, the yield decreased relative to 3,26 t/ha, which is 1,02 t/ha lower than with early sowing. Thus, when choosing sowing dates, agrometeorological forecasts for moisture reserves in the meter layer should be taken into account, and in case of low reserves, an attempt should be made to start sowing barley as early as possible. The results indicate that, on average, over 4 years, the yield change interval for the experimental variants with early sowing varied from 3,92 t/ha to 5,56 t/ha (with an average value of 4,71 t/ha). At the optimal sowing date for the zone, the yield varied from 3,16 t/ha to 5,99 t/ha (with an average value of 4,90 t/ha). Thus, sowing barley in the second ten-day period of May in LLC "AGRO-FIRM OTES-A", increases the dependence of the grain yield on the amount of precipitation that fell in the first half of the barley vegetation. Considering the effect of seeding rates on the barley yield, we note that experience has shown significant (above $NSR_{0,5}$) differences between the options. However, the change in grain yield over the years is several times greater than the changes between the experimental plots with seeding rates. With early sowing, dense crops (7 million/ha) generally reduce grain yield. With optimal sowing, sparse crops (4 million/ha) provide an increase in yield. With insufficient moisture (2020), the grain yield is higher with a reduced seeding rate. The absence of a decrease in grain yield at reduced seeding rates is due to a more optimal crop structure. Due to the increase in productive tillering of the Zhuldyz barley variety, a sufficiently high productive stem is formed on average over 4 years and a grain yield of 4,7 t/ha is ensured at an early sowing date and 5,0 t/ha at an optimal sowing date for the zone.

Conclusions

Heat and moisture supply during the growing season have a significant impact on grain yield than sowing dates and seeding rates. Early sowing extends the barley growing season and reduces the dependence of grain yield on precipitation. With the optimal sowing period (the second ten days of May) after fallow in LLC "AGRO-FIRM OTES-A", the grain harvest is provided by moisture reserves in the meter-thick layer and is determined by the conditions of heat and moisture supply in the first half of the barley vegetation period. In case of early sowing under the conditions of LLC "AGRO-FIRM OTES-A", the sowing rate of barley after the fallow predecessor should be reduced by 30-35% of the recommended one.

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