# Influence of methods of basic tillage on the yield of spring barley varieties in the zone of influence of field-protective plantations

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**Abstract.** The article discusses the results of studies on the study of modern released varieties of spring barley in the conditions of an agroforestry landscape and their response to various methods of basic tillage. It was found that in years with different climatic characteristics, there are differences in varieties in the duration of phenological phases. The longest vegetation was observed in the Bulat variety, and the shortest in the Prairie variety. The best results in terms of germination and preservation of plants were obtained in the variant with the Bulat variety, while in all varieties it was noted that these indicators were higher in the forested area than in the agrolandscape without forest belts. Analysis of the productivity of varieties showed that the studied varieties had different yields depending on the methods of tillage and the type of agricultural landscape. On the reclaimed territory and without protective plantings, the Bulat variety can be distinguished. The yield of this variety was the highest in all studied tillage options compared to other varieties. In the variant with flat-cut tillage to a depth of 0.25-0.27 m, it amounted to 2.63 t/ha under the conditions of the agricultural landscape without forest belts, and 2.89 t/ha under the protection of forest belts. Thus, it can be recommended for agricultural producers to cultivate the Bulat variety, and to carry out the main processing of light chestnut soil with a tool with flat-cutting working bodies to a depth of 0.25-0.27 m.

## 1 Introduction

At present, farmers know from their own experience that the crisis in agricultural production is growing every year. In general, the farming system is constantly disrupted, fixed and production assets are aging and failing, the optimal timing for the most important agrotechnical measures, spring field and harvesting work is missed.

But the majority of managers, specialists and ordinary grain growers realized that with the help of science it is possible to significantly reduce the vulnerability of our agriculture to droughts in a short time.

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The introduction of crop rotations with the optimal size of the fallow wedge and the development of soil-protective, moisture-saving technologies have become especially effective.

Grain harvests collected in Russia in recent years meet the requirements of the flour-grinding, cereal and feed industries. But this is not enough to provide the brewing, starch and a number of other industries with a food processing complex.

In the agriculture of the Volgograd region, the most important task is to increase the production of grain crops in every possible way with the constant introduction of new varieties, and the improvement of agricultural techniques. To this end, it is necessary to make rational use of land and machinery everywhere, to introduce correct crop rotations, to use mineral and organic fertilizers effectively, to develop a fight against soil erosion, and to create shelterbelts where necessary.

It is possible to prevent the processes of soil erosion and deflation only by a complex of agrotechnical and agroforest reclamation methods. One of the effective ways is the creation of shelterbelts in the fields of crop rotations. The studies of foreign and domestic scientists confirmed their high efficiency. In addition, field-protective plantations contribute to additional moisture accumulation, improve the microclimate and, as a result, increase the productivity of crop rotations. [2-5] The total need for shelter plantations in the Russian Federation is currently about 2870 thousand hectares, according to expert estimates, only 1233 thousand hectares were created at the end of the 20th century, which is 42.9% from the general need. [1]

The purpose of the research was to study the features and find new ways to improve the productivity of adaptive technologies for the cultivation of spring barley based on the introduction into production of new varieties and technologies for tillage on chestnut soils of the Volgograd region in the system of shelterbelts.

The experiments were laid in the conditions of chestnut soils of the Kotelnikovsky district of the Volgograd region.

The objectives of the study included:

- The study of the characteristics of the growth and development of varieties depending on the technology of tillage and the presence of shelterbelts.
- Study of tillage technologies and their influence on the agrophysical indicators of chestnut soil.
- Substantiation of the features of the formation of the yield of promising varieties of barley, depending on the technology of tillage, the presence of shelterbelts.

## 2 Materials and methods

Under the conditions of chestnut soils of the Volgograd region, a field three-factor experiment was laid, in which new adaptive and promising varieties of spring barley were considered under various technologies for tillage in a forested area.

During the experiment, the following records and observations were carried out:

- Observations of the dynamics of soil moisture were carried out by the thermostatic-weight method in triplicate. Soil sampling was carried out with a soil drill every 0.1 m to a depth of 1 m, in the main phenological phases of spring barley (before sowing, germination, budding, heading, milky ripeness, waxy ripeness, full ripeness.).
- Phenological observations of the growth and development of spring barley were carried out according to the methodology of the State Variety Network.
- Determination of the elements of the crop structure was carried out according to the generally accepted methodology. State variety testing for each variant of the

experiment. The data of the crop, reduced to standard moisture content, were subjected to mathematical processing by the dispersion analysis method.

- The biological yield was taken into account by the method of collecting ears on accounting sites, followed by manual threshing and weighing in triplicate for each repetition of the experiment. Accounting for the economic yield was carried out by the method of continuous threshing with the "Nova 340" combine. Yield data were processed by analysis of variance.
- Indicators of the main meteorological elements: temperature, precipitation, air humidity were obtained at the nearest weather station in the city of Kotelnikovo.

Scheme of experience.

In a three-factor field experiment, 3 varieties of spring barley and 3 variants of tillage were studied, according to the following scheme:

Factor A - Tillage:

- Moldboard plowing mon-8-40 (control) 0.22-0.25 m.
- Flat cutting processing with a flat cutter PGN-7.0 0.25-0.27 m.
- Processing with a disc harrow BDM-6x2 0.12-0.14 m.

Factor B - Barley Varieties:

- Prairiya (control).
- Shchedryy.
- Bulat.

Factor C - Tillage:

- Agrolandscape without forest belts (control).
- Agrolandscape with forest belts.

The production experiment was carried out in triplicate. The area of each experimental plot was 1080.0 $m^2$ (100 x 10.8 m), the registration plot was 504 $m^2$ (84 x 6 m). The location of plots in the experiment is systematic.

Sowing of spring barley in 2020 was carried out in the first decade of April (04/08/2020), in 2021 in the second decade (04/17/2021). The predecessor is winter wheat.

## 3 Results

Since 2020 and 2021 differed in weather conditions and the timing of the start of field work, the dates of the onset of phenological phases had certain differences.

An analysis of the duration of the interphase period showed that there are some differences depending on the variety and prevailing weather conditions. In 2020, the germination-earing period for varieties ranged from 61 to 70 days. The shortest period was for the Prairie variety on the field without protective forest belts - 61 days, the longest for the Bulat variety on the field under the protection of forest belts. The interphase period "heading - full ripeness" was the shortest under the protection of forest strips in the Shchedry variety for 31 days, and for the Bulat variety without protective strips, on the contrary, the longest was 35 days.

Thus, the shortest growing season in 2020 on the variant with forest belts was 97 days for the Prairie variety, and the longest for the Bulat variety was 103 days.

The weather conditions in the spring of 2021 had an impact on the duration of the interphase periods. The control variety Prairie, both in 2020 and 2021, had the shortest germination-earing interphase period, but differed in duration depending on the presence of windbreaks, which is probably due to biological characteristics. In variety Bulat, the duration of this period was the longest and amounted to 69 - 70 days. The duration of the Bulat variety period changed slightly (by 1 day).

The next interphase period: earing - full ripeness due to the weather conditions in 2021 was shorter compared to 2020. The duration of this period in the conditions of windbreaks ranged from 31 to 33 days (31 days - Shchedryy, 33 days - Bulat and Prairie). Without forest belts, the indicators varied from 33 to 35 days (33 days - Shchedryy, 35 days - Bulat). In comparison with 2020, the duration of the growing season has decreased. Thus, in the fields under the protection of forest belts, the growing season of the Bulat variety decreased the most and amounted to 97 days. For the variety Shchedryy this period was 96 days, and for Prairie it was 95 days.

The different duration of the growing season is due, first of all, to the climatic features of each particular year, as well as the presence or absence of field-protective flat plantings.

In the complex of agrotechnical practices for the cultivation of barley, on which the yield and its quality depend, the most important role belongs to the sowing density. According to many researchers, both sparseness and thickening of crops reduce crop yields. With rare standing, plants do not fully use the nutrients and moisture of the soil, a reduced yield is obtained, although the productivity of an individual plant may be high.

The density of barley plants was influenced by both the applied tillage technology and the presence of shelterbelts, as well as weather conditions during the observation period.

Field germination on average for 2 years of the study varied from 84.7 to 92.9%. The highest indicators were noted on the field with a protective strip and amount to 88.6 - 92.9%. Depending on the technology of soil cultivation, the highest field germination was ensured by flat-cut tillage of 0.25-0.27 m and provided from 3.2 million to 3.25 million plants per hectare.

Variety Bulat had the highest germination rate from 90.6 to 92.9%, while the number of seedlings was from 3.17 to 3.25 million plants per hectare. Variety Shchedry had a germination rate of 90.1 to 92.4% with the number of seedlings from 3.15 to 3.23 million plants per hectare. The lowest germination was obtained when the culture was sown on the field without protective plantings. There, the germination rate varied from 87.4 to 92.3% with the number of seedlings from 2.96 to 3.23 million plants per hectare.

Features of the growing season, in turn, affected the safety of 82.1 to 89.3% of plants in relation to the number of shoots that appeared.

The safety for harvesting was influenced by both the biological characteristics of these varieties and the technology of tillage, as well as the presence of field-protective forest plantations.

The highest preservation of plants was noted in the field with shelter plantings and varied from 85.6 to 89.3%, while the standing density before harvesting was from 2.69 to 2.90 million plants per 1 ha. On the field without forest plantations, the safety was worse and ranged from 82.1 to 86.9% with a standing density of up to 2.81 million plants per hectare.

Thus, it can be concluded that the best results of germination and preservation of spring barley plants were observed in fields with shelter forest plantations.

The value of a climate-provided crop depends on the provision of crops with moisture and heat. The Volgograd region belongs to the regions of risky farming. The main limiting factor in obtaining a guaranteed harvest for our region is soil moisture. The regulation of the water regime is a fundamental component in the technology of cultivation of any agricultural crop. The technology of basic tillage has a direct impact on the water regime.

As studies have shown, the content of available moisture differed over the years of research, depending on the applied tillage technologies and the presence of protective forest plantations.

In 2021, the amount of available moisture was greater than in 2020. This is due to the large amount of precipitation, both in the autumn-winter and in the spring-summer period.

So in 2020, during the sowing period on fields without protective plantations, the content of available moisture ranged from 86.3 to 105.9 depending on the tillage technology, in 2021 from 97.5 to 124.9 mm. In the heading phase in 2020, the amount of moisture reached 67.5 mm, in 2021 - 104.3 mm, and in the phase of full ripeness in 2020, the indicators varied from 19.4 to 27.8 mm, in 2021 from 22.1 up to 35.9 mm.

Of the studied variants of tillage without field-protective forest plantations, the highest moisture content was noted in the variant with flat-cut tillage of 0.25-0.27 mm, and in the period of full ripeness it was 27.8 and 35.9 mm.

In the field with protective plantations during the sowing period in 2020, the content of available moisture was in the range from 97.1 to 117.6 mm, and in 2021 from 105.9 to 135.6 mm. During the heading phase, available moisture reached an amount of 57.1-60.9 mm in 2020 and 92.4-109.6 mm in 2021.

In the phase of full ripeness, the best indicators of the content of available moisture in 2020 and 2021 were in the variant of flat-cut tillage of 0.25-0.27 m and reached 32.3 mm and 40.7 mm, respectively.

On average, over 2 years of research, the content of available moisture in the field with protective plantations before sowing with flat-cut processing of 0.25-0.27 m was 126.6 mm, which is 11.2 mm more than with the same method of processing, but without forest plantations. In the phase of entry into the tube, the moisture content decreased. On the field with protective plantings, it varied from 89.65 to 104.3 mm, and without protective strips from 79.75 to 100.55 mm.

By the flowering phase, the amount of available moisture decreased in all variants, however, the pattern of distribution by treatment options was preserved. So, on the field with protective forest plantations on moldboard plowing, the indicator averaged 73.5 mm, on flat-cut tillage 80.0 mm and on disc plowing 62.95 mm. In the variant without forest plantations, the indicators were 62.9 mm, 70.25 mm, 54.55 mm, respectively.

By the beginning of the phase of full ripeness, the content of available moisture was approximately at the same level and did not exceed 36.5 mm. However, there was a difference in terms of experience. The highest content was in the variant with flat cutting 0.25-0.27 mm - 36.5 mm (with forest plantations), and the lowest in disking was 20.75 mm (without plantations).

An analysis of the structure of water consumption of spring barley showed that it is very different and depends on the variety, the technology used for tillage, and the presence of shelter forest plantations. On average, over 2 years, the total water consumption varied from 1625.0 2396.0 (Prairie variety, disking, without afforestation) to 1918.0 (Bulat variety, flat-cutting treatment 0.25-0.27 m, with PZLN) $m^3$/ha.

The formation of water consumption was influenced by atmospheric precipitation and soil moisture reserves. In terms of shares, the contribution to the total water consumption was in the following ratio: the share of precipitation during moldboard plowing accounted for 52.1 to 54.0% (with protective PZLP) and from 53.0 to 54.3% (without PZLP), the share of soil moisture from 46.0 to 47.9% (with PZLP) and from 45.7 to 47.0% (without PZLP). When carrying out flat-cut processing, precipitation accounted for from 47.7 to 52.3%, for soil moisture reserves 47.7-52.3%. In the variant with soil cultivation with a combined tool, the share of precipitation was 47.8-48.5%, the share of soil moisture reserves was 51.5-52.2%. On disking, the share of atmospheric precipitation was the highest of all the studied options, ranging from 53.5 to 56.2%, and soil moisture reserves 43.8 (without PZLN) -46.5 (with PZLN)%.

One of the important indicators of water consumption is the coefficient of water consumption, which characterizes the quantitative consumption of moisture reserves for the formation of the main product. In our experience, the water consumption coefficient varied from 656.3 $m^3$/t to 878.9 $m^3$/t. The lowest water consumption coefficient is in the variant

with field-protective forest plantations, where moldboard plowing was carried out 0.20-0.22 m 656.3 m³ / t. With flat-cut processing of 0.25-0.27 m, the coefficient varied from 667.8 to 716.4 m³/t. An analysis of water consumption for the studied varieties showed that the Bulat variety is more economical in terms of water consumption under the conditions of shelter forest plantations, since the water consumption coefficient for this variety varied from 656.3 to 744.3 m³/t of grain. The control variety Prairie, on the contrary, had very high values of the indicator under consideration, depending on the technology used, this variety spent from 716.4 to 785.9 m³ of available moisture on the formation of 1 ton of products.

Thus, it can be concluded that the water regime and the structure of water consumption of spring barley depend on the biological characteristics of a particular variety, the technology of tillage, and the presence of field-protective forest plantations.

The best option for providing plants with available moisture is the option with field-protective plantings, where flat-cutting processing of 0.25-0.27 m was carried out. The moisture reserves in this option changed on average over 2 years of research from 126.6 mm at the beginning of the growing season and mm at the end. The worst variant studied is the variant with soil disking without forest plantations, since the moisture content was 91.9 mm before sowing and 20.75 mm at full ripeness, which is 5.65 mm less than in the control variant.

The most economical option for water consumption among the studied varieties, based on the data obtained, is the Bulat variety grown under the influence of field-protective plantings. The coefficient of water consumption for this variety was 656.3-744.3 m³/t, depending on tillage, and from 13.4 to 15.3 kg of grain was formed per 1 mm of productive moisture.

Analysis of the obtained yield of spring barley varieties in the experiment showed that the varieties formed a yield at the level of 1.87-2.89 t/ha. The best variant of the studied varieties is the variant where the Bulat variety was sown. The yield of the variety on the variant with field-protective plantings on average for 2 years was 2.69 for moldboard plowing, 2.89 for flat-cutting, and 2.30 t/ha for disking. The yield of the same variety, but without protective plantations, was less by 0.18 on moldboard plowing, and by 0.26 t/ha on flat-cut tillage and discator.

**Table 1.** Average yield of spring barley for 2020-2021, t/ha.

| Tillage | Without shelter plantings | | | With protective plantings | | |
|---|---|---|---|---|---|---|
| | Varieties | | | | | |
| | Prairiya | Shchedryy | Bulat | Prairiya | Shchedryy | Bulat |
| Moldboard plowing (control) 0.20 | 2.19 | 2.36 | 2.51 | 2.37 | 2.53 | 2.69 |
| Flat cutting 0.25 | 2.33 | 2.51 | 2.63 | 2.54 | 2.73 | 2.89 |
| Processing with a discator 0.12 | 1.87 | 1.97 | 2.04 | 2.11 | 2.18 | 2.30 |

NDS (05) 2020 - 0.14, NDS (05) 2021 - 0.18

The lowest yield was formed by the control variety Prairie without protective forest plantations, which, according to the tillage options, was equal to: 2.19 for moldboard plowing, 233 for flat tillage, and 1.87 t/ha for disking.

Of the studied options for tillage, flat-cut tillage of 0.25-0.27 m on the variant with forest plantations showed the highest results. The yield of Prairie is 2.54 t/ha, Shchedryy is 2.73 t/ha, Bulat is 2.89 t/ha. In the control variant, the yield was equal to 2.37, 2.53, 2.69 t/ha, respectively.

The option using disking did not provide high yields and is the worst among the studied options for tillage. The yield in this variant varied from 1.87 to 2.30 t/ha.

Thus, based on the data obtained, the following conclusion can be drawn. The most effective combination of options is the Bulat variety and flat-cutting treatment 0.25-0.27 m

in the field with field-protective forest plantations, since they provide the highest yield in the experiment - 2.89 t/ha, which is more than in the control combination (moldboard plowing and Prairie variety) by 0.52 t/ha. The option of using disking in the field without protective strips does not provide a high yield compared to other tillage options.

## 4 Discussion

The studied varieties have some differences in the dates of the onset of phenological phases, the duration of interphase periods and the growing season. The control cultivar Prairiya has the shortest growing season, the longest cultivar Bulat is 93-97 days, and the cultivar Schedry is 93-96 days.

The best option for tillage is flat-cut tillage 0.25-0.27 m in the Bulat variety on the field with protective plantations and the safety is 89.3% at a standing density of 2.9 million plants per hectare before harvesting. The worst option is processing with a BDM-6 disc harrow 0.12-0.14 m in a field without protective strips. Here, the standing density before harvesting is in the range from 2.43 to 2.62 million plants per 1 ha, or 84.7-89.3% of the number of emerging plants.

The best option for providing plants with available moisture is the variant with field-protective plantings, where flat-cut processing of 0.25-0.27 m was carried out. Moisture reserves in this variant change on average over 2 years of research from 126.6 mm at the beginning of the growing season to mm at the end. The worst variant studied is the variant with soil disking without forest plantations, since the moisture content was 91.9 mm before sowing and 20.75 mm at full ripeness, which is 5.65 mm less than in the control variant.

The most economical option for water consumption among the studied varieties, based on the data obtained, is the Bulat variety grown under the influence of field-protective plantings. The coefficient of water consumption for this variety was 656.3-744.3 $m^3/t$, depending on tillage, and from 13.4 to 15.3 kg of grain was formed per 1 mm of productive moisture.

The most effective combination of options is the Bulat variety and flat-cut tillage 0.25-0.27 m in the field with shelter forest plantations, since they provide the highest yield in the experiment - 2.89 t/ha, which is more than in the control combination (moldboard plowing and Prairie variety) by 0.52 t/ha. The option of using disking in the field without protective strips does not provide a high yield compared to other tillage options.

## 5 Conclusion

For the cultivation of spring barley in the zone of light-chestnut soils of the Volgograd region, it is necessary to recommend the high-yielding variety Bulat for sowing, and as the main tillage, flat-cut tillage with a flat cutter PGN-7.0 to a depth of 0.25-0.27 m should be used, providing a yield of protected agricultural landscape up to 2.89 t/ha and the level of profitability up to 2.13%. In the zone of chestnut soils, it is necessary to pay attention to the placement of agricultural crops on forested lands, since forest reclamation plantations provide better growing conditions and an additional increase in productivity.

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## References

1. K.N. Kulik, V.I. Petrov, *Desertification in Russia. Problems and ways to solve them*, Materials of the international scientific-practical conference of graduate students and young scientists, Agroforestry reclamation in the system of adaptive landscape agriculture: search for a new model (on the occasion of the 90th anniversary of Academician of the Russian Academy of Agricultural Sciences E.S. Pavlovsky) 5-10 (2013)
2. D.V. Mikhin, Microclimate and bioproductivity of crops in the system of forest belts, Bulletin of the Voronezh State Agrarian University, **4**, **39**, 309-313 (2013)
3. E.G. Paramonov, Forest belts and moistening of interstrip fields, Bulletin of the Altai State Agrarian University, **11**, **109**, 052-054 (2013)
4. V.B. Trots, Agroecological impact of shelterbelts, Bulletin of the Orenburg State Agrarian University, **4**, **60**, 189-192 (2016)
5. M.D. Dafa-Alla, K.N. Nawal, Al-Amin Design, Efficiency and Influence of a Multiple-Row, Mix-Species Shelterbelt on Wind Speed and Erosion Control in Arid Climate of North Sudan, Research Journal of Environmental and Earth Sciences, **3**, **6**, 655-661 (2011)