Formation of elements of the harvesting structure of spring durum wheat in agroecological conditions of the Chuvash Republic

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Abstract. The article presents for the first time data on the productivity of varieties of spring durum wheat of different morphotypes under the conditions of the northern regions of the Chuvash Republic, in order to select the most promising of them and determine the possibilities of selective and technological adaptation in the region. The experiment involved 5 varieties of spring durum wheat: 1) Bezenchuk 200 (control), 2) Bezenchuk Niva, 3) Bezenchuk 205, 4) Bezenchuk 209 and 5) Luch 25. The results of biometric and structural analysis of spring durum wheat plants on average for 2015-2017 found that the height of plants by varieties on average for three years ranged from 74.6 to 104.8 cm. Indicators of the best productive bushiness were noted for the variety Bezenchuk Niva and Bezenchuk 209. Weather conditions in 2015 and 2016 provided more favorable conditions for the formation of elements of the structure of the crop, in contrast to 2017, characterized by an abundance of precipitation and lower temperatures during the growing season. It was found that the number and weight of seeds in the head depending on the variety varied in proportion to the length of the head. The best indicators of the crop structure were found in the Bezenchuk Niva and Bezenchuk 209 varieties, where the number of seeds in the main spike was 21.8 - 22.9 and the mass of seeds in the spike 1.0 - 1.1 g. The mass of 1000 seeds amounted to options from 42.32 to 53.3 grams. The Bezenchuk Niva and Luch 25 varieties significantly exceeded the control of this indicator by 8.9 and 10.8%, respectively. Accounting for biological yields revealed the advantage of the Bezenchuk Niva and Bezenchuk 209 varieties.

1. Introduction
The annual deficit of durum wheat in the world market is currently estimated at 1.5 million tons. The shortage, especially of quality grain, will increase in the near future. This is due to the fact that there are almost no regions in the world where the expansion of durum wheat (the fastest way to increase gross production) is environmentally and economically feasible, with the exception of Russia and Kazakhstan [1]. At the same time, the need for durum wheat grain and products from it increases. The growing welfare of the population in the world creates an increased demand for quality food, including pasta made from durum [2]. The consumption of pasta in China and other Southeast Asian countries is increasing rapidly. The Arab population is growing, which has a significant migration potential, which leads to the spread and popularization of traditional dishes of the Middle East – bulgur and couscous, which are prepared from durum wheat. The so-called "flatbread" baked from durum wheat flour is popular in Italy and in a number of regions of the Middle East and North Africa, which also expands the market for durum wheat producers [3].
The average annual production of durum wheat in Russia for the last 3-4 years ranges from 500-600 thousand tons, about 800 thousand tons were produced in 2017. Export amounts to 100-150 thousand tons [4]. At the same time, grain imports from Kazakhstan in 2016 exceeded 250 thousand tons [5]. Import of pasta (mainly from Italy) annually exceeds 100 thousand tons. The demand of the Russian market for high-quality pasta (from durum) is estimated at 750-800 thousand tons, in high-quality wheat cereals (from durum and spelt) in 100 thousand tons, which is equivalent to 1.5 million tons of durum wheat. Taking into account the prospects for the development of export potential and import substitution, the volume of production of durum wheat in Russia should be at least 2.0-2.5 million tons annually, which is 3 times more than the record harvest in 2017 [6]. In this regard, along with solving the problems of increasing the production of durum wheat in the traditional regions of its cultivation, it is advisable to assess the possibility of expanding the area of this culture in the Northern regions of the Volga and Ural regions with a more favorable hydrothermal regime of the growing season. Each agricultural region has certain environmental resources for the formation of the appropriate size and quality of the harvest of a particular cultivated crop [7, 8]. The Chuvash Republic is one of these regions. Cultivation of durum wheat in a new region can be successful only on the basis of an adequate varietal type [9].

**The purpose of this work** is to study the productivity of varieties of spring durum wheat of different morphotypes in the Northern regions of Chuvashia and the selection of the most promising of them and to determine the possibilities of breeding and technological adaptation of spring durum wheat in the region.

2. **Material and methods**

Experiments on the various testing of spring durum wheat are carried out at the Student's Training and Production Center of the Chuvash State Agricultural Academy since 2015 on a medium loamy dark gray forest soil. The topsoil of the test plot has a soil reaction close to neutral, the humus content is low, mobile phosphorus is high, and exchangeable potassium is high. Microplot trials were laid according to the scheme: 1) Bezenchuk 200 (control), 2) Bezenchuk 205, 3) Bezenchuk 209, 4) Bezenchuk Niva, 5) Luch 25. The first 4 varieties are bred in the Samara NIISH, and Luch 25 - the All-Russia Scientific-Research Institute of Agriculture of the South-East. Seeds of all varieties were of the elite category. The varieties Bezenchuk 200, Bezenchuk 205 and Bezenchuk 209 belong to the variety Gordeiform, Bezenchuk Niva and Ray 25 - leukurum. For the duration of the period of “sprouting-earing” they are arranged in order of increasing period as follows: Bezenchuk 205, Luch 25, Bezenchuk 200, Bezenchuk Niva, Bezenchuk 209. Bezenchuk 209 variety carries a strong gene reduction of plant height RhtB1b and belongs to the stunted morphotype. All other varieties do not have strong genes that control plant height, its value depends on the duration of vegetation and environmental conditions during the growth of internodes and their number.

Bookmark and design of experiments, observations, and records during the growing season, harvesting and accounting of the crop were carried out according to the method of state variety testing. Mathematical processing of data was carried out according to Dospekhov. Agricultural machinery of cultivation was generally accepted for the Chuvash Republic: autumn plowing to a depth of 25-27 cm, spring harrowing and presowing cultivation. Predecessor - potatoes. Sowing was carried out in May at a soil temperature at a seed embedment depth of 8-10°C, with a norm of 5 million pieces of germinating seeds per 1 ha.

Weather conditions in 2015 were generally favorable for the growth and development of spring durum wheat plants. The second decade of May was characterized by moderately warm weather with frequent precipitation. Their sum exceeded two perennial norms. The average monthly temperature was 3.8 degrees above the long-term. In June, due to elevated temperatures, there was a lack of precipitation. Spike formation took place in conditions of insufficient moisture supply. In July, the weather was kept cool for this season with frequent and heavy rains. Wax ripeness of cereals was noted in mid-August. In general, during the period of the active growing season (May-August), the average temperature exceeded the multi-year indicator by 1.8°C and amounted to 18.2°C, the amount of precipitation was 249 mm or 115% of the multi-year norm.
Sowing of spring durum wheat in 2016 was performed in late April-early May. This year, the growth and development of field crops came under conditions of lack of moisture against the background of high temperature during the entire growing season. The least amount of precipitation was observed in the first two months of the growing season: in May, 17% and in June, 45% of the multiyear monthly norm. In July and August were - 88% - 80% of the perennial amounts, respectively. The reserves of productive moisture in the soil were remained low level. It had been raining for more than 22 days in September and 9 days were marked with precipitations more 51 mm. The total precipitation for the month amounted to 134 mm, 290% of the multi-year norm. In this regard, the harvesting work in 2016 was completed only in October [10]. In general, during the period of the active growing season of plants (May-August), the average temperature of the air was 19.6 °C, exceeding the long-term one by 3.2°C. 134.3 mm of precipitation fell, 54% of the long-year norm.

In 2017, sowing was carried out in the second decade of May. The growth and development of durum wheat plants at the beginning of the growing season (May-June) took place under conditions of excess moisture against the background of low temperatures. The second half of the growing season (July-August) in temperature and precipitation differed little from the average multiyear norms. The period of ripening of the crop (the third decade of August) coincided with heavy precipitation, accompanied by strong winds, which caused lodging of the crops. In general, during the growing season of durum wheat (May-August), the average daily temperature (15.8°C) was lower than the average multiyear values by 0.6°C. These circumstances and the relatively late date of sowing led to a prolongation of the growing season and late harvesting periods. In both years, in terms of other spring grain crops (spring soft wheat, barley), it was quite competitive in terms of grain yield and gross income per unit of cultivated area.

3. Research results
Analysis of the structure of the crop was carried out on trial sheaves taken before harvesting. The results of biometric analysis of spring durum wheat plants (Table 1) it was noted that the height of the plant varieties ranged from 74.6 to 104.8 cm. Most tall varieties are reliably marked in the variety Bezenchuk 205 and low-growing – Bezenchuk 209. Bezenchuk 209 variety carried a strong gene reduction of plant height RhtB1b and belonged to the stunted morphotype. However, a great height was not always advantage and low-growing plants were usually more resistant to lodging. In all likelihood, the lodging problem was solved without short stem forms due to directional selection for the thickness and strength of the straw, if it was only about stem lodging. Also, root lodging was extremely widespread in spring wheat with its was weak knot roots. Here, short-stalk played a positive role, especially when lodging caused by soil spreading after rains, such as in 2017, when the strength of the connection between roots and soil showed sharply weakens and short. Light stem showed undoubted advantages in plant resistance.

| Varieties    | A number of plants before harvesting(pcs / sq. m) | Plant height (cm) | Bushiness | Number of internodes(pcs) |
|--------------|---------------------------------|------------------|-----------|--------------------------|
|              |                                 |                  | General   | Productive               |                        |
| Bezenchuk 200| 349                             | 76.6             | 2.0       | 1.9                      | 3.8                    |
| Bezenchuk 205| 314                             | 104.8            | 2.1       | 2.1                      | 3.8                    |
| Bezenchuk 209| 343                             | 74.6             | 2.4       | 2.3                      | 3.5                    |
| Bezenchuk Niva| 357                            | 93.2             | 2.4       | 2.3                      | 3.5                    |
| Luch 25      | 370                             | 94.4             | 2.0       | 1.7                      | 3.6                    |
| NSR 05       | 8.9                             | 6.5              | 0.3       | 0.3                      | 0.4                    |
Also, in our studies, we determined the number of internodes of durum wheat stem. However, many researchers assign a large role in the stalk strength not so much to the number of internodes as to the thickness of the internodes and their anatomical structure [11]. In our studies, the number of internodes by varieties on average over two years varied in the range of 3.5-3.8, however, the difference in options could not be considered reliable, since changes were within the margin of field experience.

The number of shoots that form wheat plants was commonly called business, and the its process was called tillering energy.

However, not all shoots produce spikelets, therefore they distinguished between total bushiness (the number of shoots per plant) and productive bushiness (the number of spikelets on the plant), which was an important factor shaping the productivity of plants. In the experiment under study, the indicators of total and productive bushiness varied within 2.0 - 2.4 and 1.7 - 2.3, respectively. The results obtained reliably indicated that the best results of total and productive bushiness were formed by plants of the Bezenchuk Niva varieties, 2.4 - 2.3, respectively, and Bezenchuk 209, 2.4-2.3. Good tillering energy allowed these varieties, respectively, to form a larger number of productive stems, by grade Bezenchuk 209 - 788 pcs/m² and Bezenchuk Niva - 821 pcs/m². 663 productive stalks per 1 m² were formed in the control variant. The weakest tillering was observed in the Luch 25 variety, where the index of productive bushiness was 1.7 and the number of productive stems was 629 pcs / m².

Analysis of the structure of the crop is an important method for assessing the development of cultivated plants; it allowed establishing patterns of yield formation and tracing its depended on the variety of environmental factors [12, 13]. The results of the analysis of the structure of the crop on average for the studied year were given in Table 2. It followed from them that the number and weight of seeds in a head varied in proportion to the length of a head, depending on the variety. The length of the head of durum wheat varied from 3.85 to 5.1 cm. Also in our studies, we determined the productivity of the main spike, counting the number of grains and their mass. The best indicators of the structure of the crop compared with the control were reliably observed in the Bezenchuk Niva variety, where the head length was 5.1 cm, respectively, the number of seeds per head was 22.9, and the seed weight was 0.7 g.

| Varieties     | Head length (cm) | The number of grains in the main spike (pcs) | The number of grains in the main spike (pcs) | Weight of 1000 seeds (g) | Yield (t / ha) |
|---------------|------------------|--------------------------------------------|--------------------------------------------|--------------------------|---------------|
| Bezenchuk 200 | 4.6              | 20.2                                       | 0.9                                        | 48.1                     | 2.63          |
| Bezenchuk 205 | 3.4              | 16.8                                       | 0.7                                        | 42.3                     | 1.96          |
| Bezenchuk 209 | 4.4              | 21.8                                       | 1.0                                        | 46.7                     | 2.96          |
| Bezenchuk Niva| 5.1              | 22.9                                       | 1.1                                        | 52.4                     | 3.41          |
| Luch 25       | 5.0              | 18.6                                       | 1.0                                        | 53.3                     | 2.98          |
| NSR 05        | 0.7              | 1.4                                        | 0.2                                        | 3.5                      | 4.7           |

The formation of grains in the spike was affected by many factors, such as, for example, temperature. A puny grain was formed at low temperatures, lack of moisture or when it was in excess, and the mass of 1000 seeds decreased accordingly [14]. The mass of 1000 seeds was determined to characterize the fullness and size of seeds. Large, heavy seeds, having a larger supply of nutrients, produce powerful seedlings in field conditions during germination, which later develop well and provide a higher yield. In the studied the year 2015, the weather was more favorable for growing durum wheat than the conditions of 2016 and 2017, characterized by drought in 2016 and an abundance of precipitation at low temperatures during the growing season of 2017. For example, this indicator for varieties in the
conditions of 2015 varied from 45 to 60 grams, in 2016 from 41 to 53 grams and in 2017 from 38 to 46 grams, respectively. As a result, durum wheat plants formed a more complete grain with the best mass index of 1000 seeds in the agro-climatic conditions of 2015. The mass of 1000 seeds amounted to options for an average of three years from 42.3 to 53.3 grams. The Bezenchuk Niva and Luch 25 varieties reliably exceeded the control and the rest options on this indicator. Bezenchuk 205 was inferior to all other varieties in terms of the mass of 1000 seeds, which averaged 42.3 grams over the three a typical agroclimatic years.

Yield is an important criterion for assessing the cultivation of crops. For all the years studied, we managed to get a full-fledged harvest of spring durum wheat, which was almost as good as the traditional spring wheat in the Republic. The yield data of spring durum wheat for years of research was presented in Figure 1. Durum wheat varieties reacted differently to the agro-ecological conditions of atypical years of research. For example, year 2017 was the most favorable for yield, for the yield of Bezenchuk 200 variety (control) was maximum compared to the other varieties and amounted to 3.56 t/ha. Year 2017 conditions were the most favorable for shaping the yield of the Bezenchuk 205 and Luch 25 varieties. In 2015, the yields of Bezenchuk 209 and Bezenchuk Niva were 3.1 and 3.6 t/ha, respectively.

An analysis of the average yield data over the years of research revealed that the highest biological yield was reliably formed by the Bezenchuk Niva variety - 3.4 t/ha. The lowest yield (1.9 t/ha) was formed by the Bezenchuk 205 variety compared with the control.

4. Conclusion
Thus, according to the results of three-year studies, it could be concluded that the climatic conditions of the Chuvash Republic as a whole meet the biological requirements of durum wheat. All the varieties studied during 3 years formed a full grain harvest. The value of the yield, its structure identified for the production and further research (cultivation technology, selection) Bezenchuk Niva variety. Prospects for the commercial use of new varieties of durum wheat in general in the Chuvash Republic are estimated at 50-75 thousand hectares, which will ensure the needs of local pasta and cereal enterprises and export grain to other regions.

References
[1]  Malchikov P N, Vyushkov A A and Myasnikova M G Formation of models of varieties of durum
wheat for the Middle Volga region of Russia Monograph (Samara: SamNC, Russian Academy of Sciences) p 112

[2] Lozhkin A G and Malchikov P N 2018 The productivity of varieties of spring durum wheat in the Chuvash Republic Agricul. Scient. J. 12 31

[3] Lozhkin A G 2018 Prospects for the cultivation of varieties of spring durum wheat in the conditions of the forest-steppe zone of the Chuvash Republic 2018 Bullet. Bashkir State Agrarian Univer. 2 40

[4] Shashkarov L G and Malov N P 2018 Plant density, field germination and survival of spring wheat plants depending on the variety Bullet. Kazan State Agrarian Univer. 3 65

[5] Pushkarenko N N and Ivanikhov Y V 2018 Problems of technical service in agriculture and possible solutions Prospects for the development of technical service in the agro-industrial complex. Materials of the all-Russian scientific-practical conference. Chuvash State Agricultural Academy (Cheboksary) p 228

[6] Lozhkin A G, Malchikov P N and Myasnikova M G 2018 Spring durum wheat in the conditions of the forest-steppe zone of the Chuvash Republic Grain Econ. Russia 4 59

[7] Ilyin A N and Ilyina T A 2017 Air regime of the arable layer of gray forest soil with different technologies of its processing in the conditions of the Chuvash Republic Agroecological and organizational-economic aspects of the creation and effective functioning of environmentally stable territories materials of the All-Russian scientific-practical conference (Cheboksary) p 76

[8] Makushev A E and Abrosimova M S 2018 State regulation of the activities of agricultural enterprises The development of agrarian science as the most important condition for the effective functioning of the agro-industrial complex of the country materials of the All-Russian Scientific and Practical Conference dedicated to the 70th anniversary of the Honored Worker of the Higher School of the Chuvash Republic and the Russian Federation, Doctor of Veterinary Sciences, Professor Kirillov Nikolay Kirillovich (Cheboksary) p 491

[9] Malchikov P N and Myasnikova M G 2015 Varieties of spring durum wheat for the Middle Volga and Ural regions of the Russian Federation 2015 Achievem. Sci. Tech. Agricul. 10 58

[10] Ilyina T A, Ilyin A N and Vasiliev O A 2017 The effectiveness of biofertilizers in the cultivation of spring wheat Bullet. Kazan State Agrarian Univer. 3 5

[11] Shashkarov L G and Lebedeva Z G 2016 Formation of planting density and crop structure of spring wheat depending on the variety and presowing treatment of seeds Bullet. Kazan state agrarian Univer. 1 30

[12] Vasiliev O A, Ilyina T A, Zaitseva N N 2017 The effectiveness of biofertilizers in the cultivation of spring wheat Bullet. Chuvash State Agricul. Acad. 3 5.

[13] Eliseeva L V, Kayukova O V and Eliseev I P 2018 Influence of seed size on the productivity of grain legumes Innovative technologies in the field and ornamental plant growing Collection of articles on the materials of the II all-Russian (national) scientific-practical conference p 51

[14] Kuznetsov N N, Pushkarenko N N, Medvedev V I, Zaitsev P V, Vasiliev A O, Andreev R V 2018 Model of the functioning of the technological process of post-harvest grain processing in the reception and preliminary cleaning of the heap of grain Bullet. Kazan State Agrarian Univer. 4 114