Creation of new varieties of comb-shaped wheat grass (Agropyron pectinatum (Bieb.) Beauv.) as a factor of increasing the efficiency of grass growing in arid conditions

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Abstract. Perennial grasses play the most important role in solving the problem of production of energy-saturated high-protein bulky feed and biologization of agriculture. Perennial grasses are the most affordable and stable source of cheap plant food and a means of preserving soil fertility with intensive farming, which has an anthropogenic negative impact on agroecosystems. Perennial grasses play a special role as a biological means of countering the degradation of biological, water-physical and agrochemical properties of soils, their dehumidification and erosion processes. In arid climates, the most effective species of perennial bluegrass is the comb-shaped Wheatgrass (Agropyron pectiniforme Roem et Schult.). Compared to two other species used in agricultural practice – Siberian (sand) granary (Agropyron fragile (Roth) P. Candargy) and desert (narrow-leaved) (Agropyron desertorum (Ksch. ex Link.) Schult), the comb-shaped wheat grass is characterized by a wider range of growth, high productivity and environmental plasticity. In the State register of breeding achievements approved for use in Russia as of 2020, only 10 varieties of comb-shaped wheat grass are registered, which limits the effective use of this crop and makes it necessary to intensify breeding work in order to create new varieties with improved economic and useful characteristics. At the Voronezh experimental station, active breeding work is being carried out on perennial grasses to develop new varieties of comb-shaped wheat grass. Currently set up and ready to transfer to a new variety of Pridonskoy, characterized by drought tolerance, high forage and seed productivity and longevity. Thus, when the washed-out slopes were grazed, the abundant participation of the granary in the grass mixture was noted in the third year. From the fifth year, the granary dominated the herbage, and in the 10th-12th year of use, the cenoses were represented only by the granary.

Keywords: comb-shaped wheat grass (Agropyron pectiniforme Roem et Schult.), selection, new variety, arid conditions, productivity.
1. Introduction

Directions of development and efficiency of agricultural production are determined by the bioclimatic and land potential, expressed in the structure of cultivated crops, as well as market conditions. Analysis of the structure of forage crops shows that in the Voronezh region, due to the actual priority for the cultivation of annual crops, including forage crops. As of 2018, the sown area in farms of all categories for the group of cereals and legumes was 57.6% of all crops; technical-26.9%, of which sunflower-16.4%; sugar beet – 4.9% [1]. At the same time, the share of crop groups has not changed significantly in recent years. The share of perennial grasses in the total structure of crops in recent years is only from 4.6 to 5.6% [1]. For comparison, in 1976-1980, the area occupied by grasses reached 15.2% in the total structure of crops [1]. Long-term continuous cultivation of a limited range of the most productive and market-profitable cereals, technical and oilseeds, including row crops. The application of intensive technologies with extensive use of chemicalization tools without observing scientifically based fruit exchange due to their large share in the structure of arable land led to a pronounced degradation of the biological, water-physical and agrochemical properties of soils, a significant activation of their dehumidification and erosion processes [1]. Both natural conditions and, to a greater extent, anthropogenic impact contribute to the progressive development of erosion processes on agricultural land. If current trends in land use continue, the rate of soil degradation may reach critical values, which will lead to a sharp decrease in the efficiency of crop production. The problem of preserving soil fertility is typical for the entire Central Chernozem region and other regions of the country's grain belt. Another factor that increases the risks of farming is the aridization of the climate of the Central Chernozem region and other areas of the steppe and forest-steppe zones of the country, which has been pronounced in the last 50 years, and, especially in the spring and early summer periods of vegetation, leads to a decrease in crop productivity.

The implementation of the principles of environmental safety of soil protection farming systems in arid areas is possible on the basis of expanding the crops of perennial grasses, more advanced technological design of grass mixtures that help to reduce the dependence of their productivity levels on fluctuations in agrometeorological conditions [2]. The concept of biological agriculture involves diversification of crops, increased diversity and recruitment of species and varieties of plants, including perennial grasses, the most adapted to the specific conditions of their use and provides maximum environmental and economic effect [1]. To do this, it is necessary to intensify the selection and seed-growing work on the development of new varieties of herbs with simultaneous expansion of species representation based on the use of the gene pool [3, 4]. Practice shows that only by introducing varietal crops into agricultural production, it is possible to further increase the yield of feed mass and seeds by 25-30% or more [1].

In the conditions of aridization of the climate for the dry-steppe regions of the country, one of the most promising crops is wheat grass. Wheatgrass belongs to the tribe Triticeae Dum. the type subfamily of the family Poaceae Barnh., the genus Agropyron (Wheatgrass), the subgenus Agropyron Nevski. Of the 13 types of granaries, four are common in the culture: comb-shaped (broad-leaved) (Agropyron pectatum Bieb. (A. peppiniforme Roem et Schult) Beauv.), comb-shaped (Agropyron cristatum (L.) Beauv.), brittle or Siberian (sandy) (Agropyron fragile (Roth) P. Candargy), desert (narrow-leaved) (Agropyron desertorum (Ksch. ex Link.) Schult) [5]. According to the Plant List database, the genus includes 26 species [5].

Granaries are typical representatives of early-summer bluegrass grasses with a half-dormant period of up to 120 days. As of 2020, the State register of breeding achievements approved for use in Russia registered 10 varieties of comb-shaped wheat grass, 3 varieties of Siberian granary, and 8 varieties of desert granary. For arid conditions, the most effective is the comb-shaped wheat grass. This type of granary has the largest range in the wild. In culture, it also has the highest specific weight, and its yield is higher than other types of wheat grass [5, 6].

The comb-shaped wheat grass is a long-term loose-leaf semi-upper grass of winter type of development. It has a great adaptive potential and can grow in different conditions. The plant is not demanding to the soil, and can grow on sandy or stony ground. In its wild form, it is widely distributed
in the steppes on stony slopes, in dry meadows, and in areas of estuarine meadows that are briefly
flooded (for 2-4 days). It grows and is cultivated on a wide variety of soil types, but the highest yield is
in the zone of dry steppes on salty chestnut and light chestnut soils. In nature, this is the most salt-
resistant species from the granaries. Resistant to trampling, grows early and quickly in the spring. In the
conditions of semi-desert, the Caspian sea on saline soils displaces other types of vegetation. Distributed
throughout the steppe zone and southern forest-steppe of the European part of Russia, in the Crimea, the
Caucasus, the Caspian lowland, in many arid areas of the Volga, as well as Western and Central Siberia,
Central Asia (except deserts) [5, 6, 7].

Comb-shaped wheatgrass is one of the best haymaking and pasture plants, in the conditions of the
South of Russia it gives the largest amount of Otava. The most drought-resistant among cereals that are
used in crops in a mixture of alfalfa in field herbage, as well as in improving meadows and pastures of
the dry-steppe zone. It gives good hay and is suitable for grazing when cultivated in one place for 5-6
years. Perfectly protects the soil from water and wind erosion. The average yield of hay – 3.0-3.5 t / ha,
high to 7.0-8.0 t / ha, seeds, respectively - from 0.3 to 0.5-0.6 t / ha. A powerful root system that
penetrates the soil up to 2 m or more. Weight of 1000 grains 1,4-2,1 g. Blooms in June-July. It can
withstand flooding for up to 20-30 days [8].

A valuable advantage of the granary is its longevity, high drought resistance and ability to tolerate
cold, snowless winters. Having a high adaptive viability, it can grow in one place for up to 30 years,
while forming high and stable yields [8, 9].

In the Voronezh region in a natural state a comb-shaped wheat grass found on rocky slopes, since
the subzone of leached Chernozem on sandy terraces above, steppe sandy and sandy shores of the
floodplain of the don, is unpretentious to soil conditions. On poor dry soils, it develops a deep and
powerful root system that is many times larger than the ground mass. In terms of yield, it is inferior to
many top cereals, and on poor washed-out, stony and sandy soils, it is more productive than they are;
so, on the windless seropesks of the steppe of ordinary Chernozem, hay yields were 1.0-1.4 t/ha, and the
bonfire was only 0.5-0.7 t/ha. In more favorable soil conditions, the granary in the southern regions of
the Voronezh region produces about 1.8-2.0 tons of hay, and the highest harvest was recorded at 4.8
tons per hectare.

The comb-shaped wheat grass stands up well to grazing, and is also well eaten by all farm animals
on pasture and when feeding hay. It is winter-hardy, drought-resistant, and is the main component of
grass mixtures (wheat grass + alfalfa or sainfoin) in field and grassland crop rotations in the arid zone.
In forage crop rotations, the granary is sown in autumn or spring under the cover of winter or spring
crops. With early spring seedless sowing in the second year of life, it develops completely. When sown
in mixtures with top cereals and legumes, it develops much slower. In industrial crops, when the washed-
out slopes of the Oseredi valley near the city of Pavlovsk were tilled for grazing, the plentiful
participation of wheat grass in the herbage was noted for the third year; from the fifth year, wheat grass
dominated the herbage, displacing other types of grasses, and kept in sowing for a long time.

Studies conducted at the Voronezh station showed that in the 10th-12th year of use, the crops were
represented by the dominance of the granary, the dense sod of which completely protected the soil of
the slope from erosion. At the same time, fertilizing allowed maintaining the productivity of the wheat
pasture at the level of 7.0 tons of green mass per hectare. When used for grazing, granary pastures allow
three cycles of grazing pens. In the regions of the Chernozem Center, the ridge-shaped granary is an
obligatory component of mixtures of grasses sown on sandy lands, on the slopes of the subzone of the
southern forest-steppe and Chernozem steppe, on deeply drained sandy soils of floodplains [10].

Among the varieties of perennial grasses created at the Voronezh experimental station, in 1958 the
ridge-shaped Pavlovsky 12comb-shaped wheat grass was zoned. The Pavlovsky 12 variety belongs to
the East European steppe ecological and geographical group of comb-shaped wheatgrass [5] and was
created on the basis of the wild population of the don river floodplain. The variety is characterized by
high winter hardiness, drought resistance, and unpretentiousness to cultivation conditions. Under
favorable conditions, it provides a yield of air-dry mass up to 3.0-4.0 t / ha, seeds - up to 0.6-0.8 t / ha.
On poor washed-out, stony and sandy soils, it develops a deep and powerful root system that is many times higher in weight than the aboveground mass.

In the 50s and 60s at the station, varieties were created specifically for cultivation on field lands, slopes, sandy floodplain terraces, floodplains of different degrees of moisture, the severity of the alluvial process and the duration of flooding, taking into account the main environmental factors of growth. However, due to global climate change and the unpredictability of weather conditions during growing seasons, changes in farming technologies require the development of highly competitive and productive new varieties of legumes and bluegrass perennial grasses specialized for grass mixtures. An important task of wheat breeding at the present time is to create varieties of wheat that are geographically and ecologically differentiated, characterized by high plasticity and resistance to stress factors.

Recently, the main direction in the selection work of wheatgrass is the selection of more productive, plastic, responsive to moisture and at the same time highly drought-resistant forms, resistant to rust and other diseases, with an increased weight of 1000 seeds [11]. At the early stages of breeding, the selection of forms of wild wheat grass with high ecological plasticity is carried out, because plants that are well adapted to the environment, that is, with a plastic genotype, have an advantage over others. From a wide variety of wild material in breeding nurseries, samples are selected according to the timing of the onset of phenophases, productivity, a complex of morphological and economically valuable characteristics, resistance to major diseases and pests, stress factors, drought resistance, and seed productivity. The criterion of adaptability of selected genotypes in breeding is the level of their productivity. Preference is given to the breeding material that has the maximum ecological fitness [12]. To create sustainable agrophytocenoses for food purposes in arid conditions, it is important to select certain types of perennial grasses and create promising varieties adapted for each landscape and geographical zone [13].

It is established that a significant role in the formation of the crop of green mass and seeds of wheat grass is played by the bushiness of plants. There is a very close positive relationship between the yield of the total dry mass of plants and the number (total and productive) of stems, which is confirmed by fairly high correlation coefficients of these characteristics (from 0.5 to 0.78) [11]. A comparative species assessment of the granary showed a different species ratio of the granary to the same environmental factor – the air temperature of the growing season. The closest correlation between the grain crop yield was observed with the average daily air temperature during the May growing season. It was $r = -0.95+0.11$ in the comb-shaped wheat grass [12].

**Purpose of work.** Creation, propagation and introduction into production of intensive varieties of comb-shaped wheat grass of a new generation that combine early maturity with high drought resistance, have high feed and seed productivity and other positive features and properties.

2. **Methods and materials**

The climate of the Voronezh region is characterized by continentality, which increases from the North-West to the South-East, warm summers and rather cold winters. In general, the climatic conditions are favorable for the cultivation of most agricultural crops. The main limiting factor for the cultivation of agricultural crops is insufficient water supply. The average annual precipitation is 570 mm in the North and 420 mm in the South of the region. From may to September, 240 mm of precipitation falls, and in the dry period, 136 - 179 mm of precipitation. A characteristic feature is the unevenness of precipitation by year and season.

The average annual air temperature varies from $+5 \, ^{0}\text{C}$ in the North to $+7 \, ^{0}\text{C}$ in its southern regions. The lowest temperature drops to $-400$, the highest is $+400$ (the absolute maximum in the South of the region is $+420$), the sum of active temperatures ranges from $2600 \, ^{0}\text{C}$ to $3000 \, ^{0}\text{C}$. Almost every year there are droughts and dry spells. Droughts are very dynamic (May, June, July), in the southern regions their duration reaches 70-80 days. Every third year they are intense.

Studies with wheat grass were carried out in the field crop rotation. The soil cover of the field area is ordinary Chernozem, medium-thick, medium-loamy, low-altitude. The content of $P_2O_5$ in the soil is average, $K_2O$ is increased. The reaction of the pH of the upper horizon water extract is 5.8-6.4.
The main selection schemes that are generally accepted in breeding research institutions and state testing are used in the scientific work.

3. Results and discussion
In order to fulfill these tasks, in 2011 we started to study the breadbasket, the demand for which has increased significantly in recent years. A collection nursery of 7 samples obtained from the Fund of the V. R. Williams research Institute of feed and the Pavlovsky 12 variety was laid. After 4 years of study and free re-pollination of samples, a complex hybrid population of wheatgrass called SGP-8 was formed. In parallel, an individual selection of highly productive and drought-resistant samples from the variety of wheat grass Pavlovsky 12 was carried out.

In 2015, a competitive variety testing of the best samples with increased feed productivity and drought resistance was launched. Seeds are being propagated and accumulated for transfer in 2020 of a promising variety to the State variety testing with the preliminary name of the comb-shaped wheatgrass grass Pridonsky variety.

In the competitive variety testing, the yield of green and dry mass (by years of life, mowing), seed productivity (by years), the nature of regrowth in the spring and after each mowing, the height of forage grass stands (by mowing) or seed - before harvesting were determined. The yield of green and dry mass by years of life of grass stands and individual mowing was a complex system of interaction of both genetic (varieties) and hydrothermal factors.

According to the results of accounting, in the first mowing, the yield of green mass of the standard varied from 4.29 to 14.14 t/ha, in SGP-8 from 4.65 to 15.59 t/ha, in the Pridonsky variety from 4.91 to 15.36 t/ha, in the second mowing, respectively, 1.19-4.72; 1.34-5.16 and 1.36-5.19 t / ha. The first slope was always higher in actual value compared to the second slopes. The average yield of green mass according to the Pavlovsky 12 standard was 18.86; 16.74; 5.48 t/ha, for SGP-8-20.74; 18.13; 5.99 t/ha, for the Pridonsky variety – 20.55; 18.55; 6.27 t/ha (table 1). The excess of the average annual indicator in favor of the Pridonsky variety fluctuated over the years 0.79-1.81 t / ha or 9.0-14.4%.

| Year of use | The name of the sample | Green mass, t /ha |
|-------------|------------------------|------------------|
|             | The first harvest       | The second harvest | Average for 2 harvests | % to St. | Deviation from St., t/ha |
| 2016        | St.                    | 14,14            | 4,72               | 18,86    | 100,0                | +/-0  |
|             | SGP-8                  | 15,59            | 5,16               | 20,74    | 110,3                | 1,88  |
|             | Pridonsky             | 15,36            | 5,19               | 20,55    | 109,0                | 1,69  |
|             | NSR45                  | 1,74             |                    |          |                      | 0,62  |
| 2017        | St.                    | 12,20            | 4,54               | 16,74    | 100,0                | +/-0  |
|             | SGP-8                  | 13,45            | 4,68               | 18,13    | 108,3                | 1,39  |
|             | Pridonsky             | 13,74            | 4,81               | 18,55    | 110,8                | 1,81  |
|             | NSR45                  | 0,938            |                    |          |                      | 0,299 |
| 2018        | St.                    | 4,29             | 1,19               | 5,48     | 100,0                | +/-0  |
|             | SGP-8                  | 4,65             | 1,34               | 5,99     | 109,3                | 0,51  |
|             | Pridonsky             | 4,91             | 1,36               | 6,27     | 114,4                | 0,79  |
|             | NSR45                  | 0,53             |                    |          |                      | 0,172 |

The average yield of dry mass varied significantly over the years (table 2). This is due to the fact that the shoots of the first reproductive mowing have an increased moisture content and the percentage yield of dry matter is always lower. Since the shoots of the second mowing are formed during high summer temperatures, they are more xeromorphic and have a higher dry matter content, as well as genetic and age-related causes. The thermal factor has a significant impact on this process.
Table 2. Yield of dry matter of varieties of comb-shaped granary (competitive variety testing 2015-2018)

| Options | mowings | Dry matter by year, t / ha | Average for one year | deviation from St., C / ha |
|---------|---------|---------------------------|----------------------|---------------------------|
|         |         | II | III | IV | t / ha | % to St. |       |
| St.     |         | 1  | 2   |     | 1     | 3       | 4      | +/-0 |
|         |         | 4.30 | 3.42 | 1.31 | 3.01 | 100.0 |       |
|         |         | 2   | 1.92 | 1.80 | 0.58 | 1.43 | 100.0 |       |
|         |         | Total | 6.22 | 5.29 | 1.89 | 4.45 | 100.0 |       |
| SGP-8   |         | 1  | 2   |     | 1     | 3       | 4      |       |
|         |         | 4.59 | 3.81 | 1.39 | 3.26 | 108.3 | 2.5   |
|         |         | 2   | 2.15 | 1.86 | 0.65 | 1.55 | 108.4 | 1.2   |
|         |         | Total | 6.74 | 5.67 | 2.04 | 4.82 | 108.3 | 3.7   |
| Pridonsky | 1   | 4.73 | 3.88 | 1.48 | 3.37 | 112.0 | 3.6   |
|         |         | 2   | 2.28 | 1.93 | 0.64 | 1.62 | 113.3 | 1.9   |
|         |         | Total | 7.01 | 5.81 | 2.12 | 4.99 | 112.1 | 5.4   |
| The range of variation dry matter (%) over the test period | The first harvests | 28.02 – 30.81 |
| The second harvest | 39.76 – 49.16 |

In the variety Pavlovsky 12 (standard), the yield of dry matter in the first mowing varied from 4.30 t / ha (second year of life of the herbage) to 1.31 t/ha (fourth year of life), in the second from 1.92 to 0.58 t / ha. In the variety type SGP-8 and the promising variety Pridonsky (selection from Pavlovsky 12), the range of dry mass yields by mowing, respectively, was 4.59-1.39; 4.73-1.48 t / ha, and 2.15-0.65; 2.28-0.64 t/ha.

The extreme indicators of the percentage of dry matter in the first mowing varied by year in the standard from 28.02 to 30.63 %, in the SGP-8 from 28.31 to 29.85% and in the Pridonsky variety from 28.23 to 30.81%. In the second mowing, the percentage of dry matter in all years was significantly higher. The fluctuations were 39.76-49.16 for the standard, and for the SGP-8 39,82-48,41 and varieties of Pridonsky 40,12-47,45%. Fluctuations in the dry matter content by mowing make it necessary to use only your own indicator when calculating the yield and get the feed mass indicator both by mowing, and then averaged or in total for certain periods of the use cycle. This allows you to level out the possible error, since the first mowing, although the yield of dry matter is lower, the yield of dry mass is higher compared to the second mowing.

Thus, as a result of the conducted research, a new variety of comb-Shaped prydonsky was developed, which is currently being prepared for transfer to the State Commission of the Russian Federation for registration in the State register of breeding achievements approved for use. A new variety of granary Pridonsky is characterized by the following indicators: medium-density Bush, erect, height in the phase of complete sweeping 95-110 cm. The growing season when mowing for hay in the beginning-full earing phase is 47-55 days. It Mature for seeds in the first decade of July, has a stable seed productivity, good winter hardness and drought resistance. The new variety can be used as a component in grassland mixtures, in field herbage for green feed, hay, bulky canned feed, as well as for sowing on eroded and low-fertile land in arid conditions.

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