PRODUCTIVITY OF GRAIN CROPS IN THE CONDITIONS OF THE TRAINING AND EXPERIMENTAL FIELD OF ORENBURG STATE AGRICULTURAL UNIVERSITY

O A Rekunova, G F Yartsev, R K Baikasenov, T P Aisuvakova, B B Kartabayeva, V I Tseiko, V M Kosolapov

All-Russian Research Institute of Phytopathology, Moscow region, 143050, Russian Federation
E-mail: aysuvakova.t@yandex.ru

Abstract. The relevance of the topic of scientific research is associated with the biological characteristics of the studied grain crops in specific natural and climatic conditions. The purpose of this work was to identify the potential capabilities of various grain crops in terms of yield and quality indicators of grain in the central zone of the Orenburg region. Food security of the population in the overwhelming majority of countries is most often associated with the provision of grain. At present, despite the active introduction of modern agricultural equipment and innovative technologies into the world agricultural production, it is not possible to achieve a significant increase in gross grain harvests. The level of its production is still insufficient to fully meet the growing needs of the rapidly growing population. According to the expert assessment of domestic scientists, in the conditions of modern natural and anthropogenic changes in the environment, Russia can play an important role in stabilizing the world grain production, which has sufficiently high natural, intellectual and technical resources for this. Their effective and rational use on the basis of nature-like, ecologically-oriented agricultural technologies can make a significant contribution to increasing food stability. Meeting the needs of cultivated plants in the elements of mineral nutrition was reduced mainly to the mobilization of soil fertility, i.e. depletion of humus reserves. As a result, in most of the grain-sowing regions of Russia, and primarily in the regions of the steppe zone, its negative balance has developed. It is quite obvious that these circumstances are a serious obstacle to sustainable grain production and can lead to even greater degradation of disturbed soils, disruption of the biological balance in agroecosystems and a reduction in biological diversity.

Keywords: crop productivity, grain crops, biological diversity, food stability.

1. Location and climatic conditions of the area
The territory of the educational and experimental field of the OGAU is located in the southeastern part of the Orenburg Cis-Urals and is part of the Orenburg administrative region. It is a wavy-ridged plain lying at an altitude of 200 to 400 m above sea level, dissected by erosional valleys and ravines. Almost in the middle of the Southern Urals there is the General Syrt Upland, the watershed ridges and ridges of which alternate with the vast leveled spaces of the terraces of large rivers [1, 6].
The Orenburg region is distinguished by its continental climate, which is due to the significant distance of its territory from the seas and oceans. In the winter period it is exposed to the influence of the cold Siberian anticyclone, in the summer - to the strongly heated air coming from Kazakhstan and Central Asia.

One of the indicators of the continentality of the climate is a large annual temperature amplitude (the difference between the average temperatures of the warmest and coldest months). For Orenburg, this amplitude, according to long-term average data, is 36°С. The absolute amplitude (the difference between the absolute maximum and the absolute minimum) reaches 87 °C.

The average long-term temperature of the warmest month (July) is 20.9° C, and the coldest (January) is 14.9° C. The warm period (the average daily temperature is above 0° C) accounts for 206 days, the cold - 159 days. The beginning of the spring growing season (the transition of the average daily temperature through 5° C) is observed on April 17-19, the end of the autumn growing season - October 10-13. The beginning of active vegetation (the transition of the average daily temperature through 10° C) occurs in the spring from April 30 to May 2, in the fall - from September 22 to 25. The sum of positive temperatures above 5° C is 2600-2800° C, the sum of temperatures above 10° C is 2400-2600° C.

The average annual precipitation is 367 mm with sharp fluctuations in one direction or another, the value of the GTC is 0.6 -0.8. At the same time, 60% of precipitation from their annual amount falls in the warm period.

The main source of water supply for plants throughout the summer period is moisture accumulated by spring in the root layer of the soil. Therefore, in the zone of insufficient moisture, the spring moisture reserves largely determine the conditions for the formation of the crop. [1-5].

2. Experiment scheme, observation and research technique

2.1 Experiment scheme and research methodology

Research work was carried out at the Department of Agrotechnology, Botany and Plant Breeding in 2019 in the conditions of the educational and experimental field of the Orenburg State Agrarian University. A one-factor experiment was established with various crops. Experience scheme:

1. spring soft wheat, cultivar Saratovskaya 42 (control);
2. spring durum wheat, Marina variety;
3. barley, Salome variety;
4. oats, grade Show Jumping.

The experiment was carried out in three replications, the accounting plot area was 60 sq. m.

The soil of the experimental site is southern chernozem, medium-thick, calcareous, heavy loamy with a humus content of 4.4%, mobile phosphorus - 4.5%, nitrate nitrogen - 1.35, exchangeable potassium - 35 mg per 100 g of soil. The reaction of the soil solution is slightly alkaline (pH = 7.8).

2.2 Research methodology

1. The seeding rates were calculated taking into account the sowing qualities of the seeds taken from the certificate of the seed condition. The numerical rate index was adopted as 4.0 and 4.5 million germinating seeds per hectare. Calculation of the seeding rate is carried out according to the formula:

\[
HB = \frac{A \times M_{1000} \times 100}{\Pi G}
\]

\(HB\) – weight seeding rate of seeds, kg / ha;
\(A\) – numerical norm index, million germinating seeds per hectare;
\(M_{1000}\) – weight of 1000 grains, grams;
\(\Pi G\) – sowing suitability, %.

\[
\Pi G = \frac{\Psi \times B_{-}}{100}
\]

\(\Pi G\) – sowing suitability, %;
B – seed germination, %.

2. In the experiment, the following phenological phases of development were noted: shoots, tillering, stemming, earing, flowering, milky ripeness, waxy ripeness and full ripeness. The date when 10% of the plants had signs of this phase was taken as the beginning of the phase, and at least 75% were taken as the complete onset. [11-14].

3. Field germination was calculated by dividing the number of emerged plants by 1 sq. m on the number of sown germinating seeds and expressed as a percentage.

4. Before harvesting by counting and dividing the number of preserved plants per 1 sq. m, the number of emerging seedlings was determined by the safety of plants.

5. The biological yield and the structure of the yield was determined by selection, counting and analysis of plants from 1 sq. m taken before cleaning. [eight].

6. Determination of gluten, its quantity and quality. Gluten is a protein substance of wheat grain, which is obtained by washing the dough in water. The optimal ratio of gluten in the grain gives a good bread. Gluten contains two forms of proteins: gliadin and glutenin. To determine the quantity and quality of gluten, you need to take 30 g of grain, pass them through the mill, that is, prepare meal from the grain, weigh 25 grams from it, add 14 ml of water to them, having a room temperature of 18 - 200C. Then the dough is kneaded, rolled into a ball and set for 20 minutes to settle. After twenty minutes, they begin to wash the gluten in water. They are washed until the water becomes cloudy and the shells are separated. Then the washed gluten is determined as a percentage of the total weight of the sample, this will be the amount of gluten. Then they begin to determine the quality of gluten: 4 grams are weighed from the total gluten, rolled into a ball and put into water for 15 minutes to settle. After 15 minutes, the quality of the gluten is determined on the PEC-ZA device and the deflection of the arrow is recorded.

7. Determination of natural weight. Grain is poured into the cylinder from the bucket in an even stream, without jolts, up to a line inside the cylinder, indicating the capacity of the filler. The knife is quickly, without shaking the device, removed from the slot and after the load and grain fall into the measure, the knife is again inserted into the slot with the same precautions. Individual grains, which at the end of the movement of the knife will fall between the knife blade and the edges of the gap, are cut with a knife. The measure together with the filler is removed from the nest, overturned, holding the knife and filler, and the excess grain remaining on the knife is poured. The filler is removed, the grains lingering on the knife are removed and the knife is removed from the slot. The measure with grain is weighed and the full-scale weight is established. The weighing of grain in determining the full-scale weight on a liter purke is carried out with an accuracy of 0.5 g [7-10].

8. Economic efficiency was calculated on the basis of technological maps.

9. Mathematical processing of the results was carried out by the method of analysis of variance according to B.A. Dospekhov on a PC.

2.3 Agrotechnics of experience. Variety

The predecessor of spring durum wheat in the department's crop rotation was winter wheat. Spring soft wheat followed durum wheat, while barley and oats followed spring soft wheat.

In autumn, they carried out moldboard tillage to a depth of 25-27 cm. At the end of April, when the physical ripeness of the soil approached, the moisture was covered in two tracks with harrows BZSS - 1.0. Presowing cultivation was carried out on May 21 with a KPS-4 cultivator to a depth of 5 - 6 cm.

In 2019, sowing was carried out on May 21 with a seeding rate of 4.5 million viable seeds per 1 ha of soft, durum wheat and barley, and oats - 4.0 million / ha at a depth of 5 - 6 cm, by the Austrian Wintersteiger seeder.

Harvesting was carried out with a Terrion 2010 combine in the phase of full grain ripeness on August 25, 2019.

Saratovskaya 42. Created by breeders of the Research Institute of Agriculture of the South-East (Saratov) by the method of complex stepwise hybridization with the participation of varieties Saratovskaya 29, Sarrubra, Albidum 43. It has been cultivated in production for almost 50 years, was
distributed in 31 regions, the territory and the republic of the former USSR on an area of about 4.5 million hectares. In the Orenburg region, for many years, it occupied more than half of the sowing area of spring soft wheat. Recommended for cultivation since 1973. A variety of albidum. The bush is upright. The leaf is short, narrow, with rather dense pubescence and a weak waxy coating, of a bluish-green color. The spike is cylindrical, slightly tapering towards the top, of medium density and medium length, in the upper part it has small osteiform formations. The grain is shortened in shape, with a wide shallow groove, weight of 1000 pieces, 30–37 g. In terms of grain yield, for many years it served as a standard for variety testing of spring soft wheat in the Orenburg region. In dry years, the Saratovskaya 29 variety turns out to be more productive. Plant height is about 100 cm. Mid-early: the growing season is 82–91 days, before heading is about 45 days. Resistant to drought, plant lodging and grain shedding. Sufficiently resistant to damage from brown and stem rust, dusty smut, to damage from the Swedish fly. Milling and baking qualities are high. The protein content in the grain is about 14%, the strength of the flour is on average 360 units of the alveograph. The nature of the grain is 810 g / l. Refers to varieties of strong wheat.

Marina. Pedigree: Valentine x Gordeiform 1434.

Included in the State Register for the Middle Volga (7) and Ural (9) regions. Recommended for cultivation in the Samara region, Semi-arid and Arid zones of the Chelyabinsk region.

A variety of leukurum. The bush is upright. The plant is medium-sized. Solomina is fully completed. The pubescence of the superior node is absent or very weak. The wax coating on the leaf blade and sheath of the flag leaf, the neck of the straw and the spike is very strong. The ear is pyramidal, of medium length, white, of medium density. Awns are white, longer than a spike. The lower spikelet scales are lanceolate; the pubescence of the outer surface is absent. The shoulder is sloping, narrow. The tooth is straight, short, of medium length. The caryopsis is elongated, white, the crest is absent or very short. The mass of 1000 grains is 39-51 g.

The average yield in the regions of admission is 18.6 c / ha, at the level of the average standard. In the Samara region, the increase to the Bezenchukskaya 182 standard was 1.4 c / ha, in the recommended zones of the Chelyabinsk region to the Omsk Amber standard - 1.9 c / ha with a yield of 11.7 and 28.2 c / ha, respectively. The maximum yield of 52.1 c / ha was obtained in the Chelyabinsk region in 2006. Mid-ripening, vegetation period 77-93 days, ripens 1-2 days later varieties Bezenchukskaya 182. Moderately resistant to lodging and drought, at the level of standards. The pasta quality is quite satisfactory. Moderately susceptible to leaf rust; susceptible to head smut, powdery mildew and septoria blight. [17, 19, 20].

Salome. Included in the State Register for the Northwest (2) region. Recommended for cultivation in the Leningrad region.

A kind of nutance. The bush is intermediate. Sheaths of lower leaves without pubescence. The anthocyanin coloration of the flag leaf ears is strong, the waxy coating on the vagina is medium - strong. The plant is short and of medium length. The ear is cylindrical, of medium density, with a strong waxy coating. Awn compared to a spike of medium length - long, serrated, with an anthocyanin coloration of the tips of medium intensity. The first segment of the spikelet is of medium length, with a medium curvature. The sterile spikelet is parallel. Pubescence of the main setae of the weevil is long. The anthocyanin coloration of the nerves of the outer floral scales is weak - medium. The serration of the inner lateral nerves of the outer floral scales is absent or very weak. The caryopsis is very large, with a non-pubescent abdominal groove and an enveloping lodicula. The mass of 1000 grains is 43-55 g. The maximum yield - 79.5 c / ha - was obtained in 2015 in the Leningrad region. The mid-ripening vegetation period is 74-89 days. Resistant to lodging. Drought-resistant. Protein content - 8.0-12.5%. [15-18].

Concur. Created jointly by breeders of the Research Institute of Agriculture of the Central regions of the nonchernozem zone (Moscow region) and the Ulyanovsk Research Institute of Agriculture, as well as the Skakun variety. Recommended for cultivation in the Orenburg region since 2009 for grain and fodder purposes. A variety of mutika (the grain is filmy, the panicle is spreading, awnless, the color of the grain is white). The bush is intermediate. The plant is medium-sized. The broom is double-
sided, the arrangement of the branches is half-raised. Spininess is absent or very weak. Large caryopsis: 1000 pieces weigh 35–42 g, or 1–7 g higher than the Astor standard. Over the years of testing, it increased the grain yield from 0.5 to 6.0 c / ha, depending on the zone. The maximum yield is 25.2 c / ha, obtained in 2007 at the Kvarkensky variety plot. Mid-ripening: growing season 68–77 days, ripens at the same time as the standard. Lodging resistance is above average. Susceptible to head smut, crown rust and fire blight. The grain is 456-504 g / l, or 6-28 g / l higher than the standard. The protein content in the grain is 18%, the hulliness is 27%, the cereal yield is about 60%, the taste of porridge is 5 points, the digestibility is 2.6 points. It is not classified as one of the most valuable varieties of oats in terms of quality [21-29].

3. Research results and their analysis

Field germination of seeds of grain crops was high and averaged 89.3%, which is associated with favorable weather conditions during the sowing - germination period (Table 1). The highest field germination was observed in barley and spring soft wheat, where it was 92.2 and 91.1%, respectively.

| Culture, variety      | Number of seeded germinating seeds pcs. / 1 sq. m | The number has risen plants per 1 sq. m | Number saved plant for cleaning pcs / per 1 sq. m | Field germination, % | Save plants, % | Overall survival, % |
|-----------------------|---------------------------------------------------|----------------------------------------|---------------------------------------------------|----------------------|----------------|-------------------|
| yar. soft wheat, Saratovskaya 42 (c) | 450                                           | 410                                      | 238                                               | 91.1                  | 58.0           | 52.9              |
| yar. durum wheat, Marina | 450                                           | 390                                      | 321                                               | 86.7                  | 82.3           | 71.3              |
| barley, Salome         | 450                                           | 415                                      | 400                                               | 92.2                  | 96.4           | 88.9              |
| oats, Concur           | 400                                           | 349                                      | 200                                               | 87.3                  | 57.3           | 50.0              |

For harvesting, the number of preserved plants in grain crops was different. It was the smallest in oats and amounted to 200 pcs / m², which is not surprising, since oats are moisture-loving plants. Its transpiration coefficient is 474. The largest number of preserved plants, 400 pcs / m², is noted in drought-resistant barley, the transpiration coefficient of which is 400.

Therefore, the safety of grain crops changed in a similar way. The highest it was in barley - 96.4%, and the lowest - 57.3% - in oats.

The overall survival of grain crops was closely related to the safety of plants and changed in a similar way depending on the studied crops.

3.1 General and productive bushiness of grain crops

The tillering process consists in the fact that the bud lying at the base of the first leaf increases in size, pushes it back and forms the first lateral shoot. Productive bushiness is the average number of normally developed grain-producing stems per plant. Vavilov P.P. (1979). The productive bushiness of spring wheat was low, and that of gray crops was high. For example, the productive tillering of soft and durum wheat was 1.04 and 1.0 units, and for barley and oats - 1.52 and 1.73 units, respectively (Table 2). Our data are consistent with the data of P.P. Vavilov, where he indicates that barley and oats usually have 2 - 3 productive stems, and spring wheat - 1.
Table 2. Total and productive tillering of grain crops in 2019

| Variety            | The number of surviving plants for harvesting, pcs / m² | The total number of stems pcs / m² | Number productive stems, pcs / m² | General bushiness | Productive bushiness |
|--------------------|--------------------------------------------------------|----------------------------------|----------------------------------|--------------------|----------------------|
| yar. soft wheat, Saratovskaya 42 (c) | 238 | 339 | 248 | 1,42 | 1,04 |
| yar. durum wheat, Marina | 321 | 331 | 321 | 1,03 | 1,0 |
| barley, Salome | 400 | 760 | 608 | 1,9 | 1,52 |
| oats, Concur | 200 | 380 | 345 | 1,9 | 1,73 |

The number of productive stems per unit area was low in spring soft wheat and amounted to 248 pcs / m², while in barley it was 608 pcs / m².

The value of total tillering in all studied crops was higher than productive, and varied from 1.03 to 1.9 units.

The crop structure is a complex of elements that characterize the productivity of a crop. The main elements of the yield structure are: productive bushiness, the number of grains in an ear, the mass of grain per plant, the mass of 1000 grains.

Cereal yields, due to unfavorable climatic conditions in 2019, were low, with the exception of oats.

An extremely low biological yield of 5.1 c / ha was obtained from spring durum wheat. The lowest yield of durum wheat was obtained due to the small number of grains in an ear of 6 pcs. and the smallest mass of 1000 grains is 26.5 gr. The biological productivity of spring soft wheat and barley was practically equal and amounted to 10.4 and 10.6 c / ha (Table 3).

The highest biological yield of 44.1 c / ha was obtained from oats. The highest yield was obtained due to the largest number of grains in a panicle of 41 pcs. and a high mass of 1000 grains of 31.2 gr.

Economic productivity, like biological productivity, also varied depending on the studied crops. It was the highest in oats (32.9 c / ha), and the smallest in durum wheat (3.2 c / ha).

The structural elements of plants, such as plant height, spike length, and the number of spikelets per spike, also varied significantly in the studied grain crops. For example, the height of durum wheat plants was 35 cm, and for oats - 69 cm. The number of grains in an ear of durum wheat and barley was 6 and 5 pcs., While in soft wheat it was 15 pcs.

Table 3. The structure of the harvest and the yield of grain crops in 2019

| Variety            | Number productive stems, pcs / m² | Plant height, cm | Ear length (panicle), cm | The number of spikelets per ear (panicle) | The number of grains per ear (panicle), g | Grain weight per ear (panicle), g | Weight of 1000 grains, g | Biological yield, c / ha | Economic productivity, c / ha |
|--------------------|-----------------------------------|-----------------|------------------------|------------------------------------------|-------------------------------------------|----------------------------------|--------------------------|--------------------------|---------------------------|
| yar. soft wheat, Saratovskaya 42 (c) | 248 | 56 | 5,3 | 9 | 15 | 0,42 | 27,9 | 10,4 | 8,9 |
| yar. durum wheat, Marina | 321 | 35 | 4,4 | 8 | 6 | 0,16 | 26,5 | 5,1 | 3,2 |
3.2 Quality indicators of grain

Gluten creates a supple, sticky dough. Wheat gluten is a water-insoluble protein group chemical. It is gray or light yellow. This substance is very important in the production of bread and baked goods.

In the study year, spring durum wheat formed the largest amount of wet gluten, 41.2%, which is 14% more than spring soft wheat, where the amount of gluten was 27.2% (Table 4).

The quality of gluten is usually understood as a combination of its physical properties: extensibility, elasticity, viscosity, cohesion, as well as the ability to preserve the original physical properties in the process of washing and subsequent curing. Soft wheat formed gluten of the first quality group, and durum wheat - the second quality group.

Table 4. Qualitative indicators of grain of soft and durum wheat

| Variety                          | Raw gluten number, % | Nature, g / l |
|----------------------------------|----------------------|--------------|
| yar. soft wheat, Saratovskaya 42 (c) | 27,2                 | 718          |
| yar. durum wheat, Marina         | 41,2                 | 620          |

The natural weight of the grain did not meet the requirements of high quality wheat and was below 750 g / l. The natural weight of soft wheat grain entered restrictive conditions and amounted to 718 g / l. Therefore, its grain went to the third grade. The natural weight of durum wheat did not even enter the restrictive conditions and was below 710 g / l, and therefore the grain went to the fifth grade.

4. Conclusion

The studies we conducted in 2019 in the conditions of the educational and experimental farm of the OGAU allowed us to draw the following preliminary conclusions and recommendations.

1. Agroclimatic conditions in 2019 developed as follows. By the time of sowing grain crops, the soil was sufficiently warmed up and saturated with available moisture, which created favorable conditions for swelling and germination of seeds. As a result, the germination rate was high enough.

Subsequently, there was practically no precipitation, until July, when it was already late, which created unfavorable conditions for the formation of the harvest.

2. Field germination of grain crops was high and averaged 89.3%. The highest field germination was observed in barley and spring soft wheat, where it was 92.2 and 91.1%. The largest number of preserved plants, 400 pcs / m², was noted in drought-resistant barley, and the smallest was in oats and amounted to 200 pcs / m².

3. Productive tillering of spring wheat was low, and of gray crops - high. Productive tillering of soft and durum wheat was 1.04 and 1.0 units, and for barley and oats - 1.52 and 1.73 units respectively. The value of total tillering in all studied crops was higher than productive, and varied from 1.03 to 1.9 units.

4. Grain yields were low, with the exception of oats. The economic yield of spring durum wheat was 3.2 c / ha, barley - 6.6 c / ha, and oats - 32.9 c / ha.
The structural elements of plants also varied significantly in the studied grain crops. So, the height of durum wheat plants was 35 cm, and for oats - 69 cm. The number of grains per ear in durum wheat and barley was 6 and 5 pcs., While in soft wheat it was 15 pcs.

5. The greatest amount of gluten (41.2%) was formed in spring durum wheat with the second quality group, while in spring soft wheat - 27.2% with the first quality group. The natural weight of grain of soft wheat entered the restrictive conditions and amounted to 718 g / l. The bulk density of durum wheat did not even enter the restrictive conditions and was below 710 g / l.

6. The calculation of economic efficiency in 2019 showed that the profit was obtained from the cultivation of spring soft wheat and oats. The greatest profit was obtained on oats, where the profit per hectare amounted to 16201.65 rubles, per 1 centner - 492.45 rubles, the level of profitability was 312.6% and the return on costs with products was 4.13 rubles.

References
[1] Agroclimatic resources of the Orenburg region. - L.: Gidrometeoizdat, 1971.
[2] Semenov A.M., Sokolov M.S., Spiridonov Y.Y., Glinushkin A.P., Toropova E.Y. Healthy soil-condition for sustainability and development of the argo- and sociospheres (problem-analytical review) // Biology Bulletin. 2020. T. 47. № 1. p. 18-26.
[3] Toropova E.Y., Glinushkin A.P., Selyuk M.P., Kazakova O.A., Ovsyankina A.V. Development of soil-borne infections in spring wheat and barley as influenced by hydrothermal stress in the forest-steppe conditions of western Siberia and the Urals // Russian Agricultural Sciences. 2018. № 44. P.241.
[4] Aseeva, T.A. Potential productivity and ecological sustainability of grain varieties under conditions of the middle amur region / T.A. Aseeva // Far Eastern Agrarian Bulletin. - 2012. - No. 1. - p. 9-12.
[5] Baranovsksy, A.V. Comparative productivity of spring grain crops in arid conditions of the Luhans region / A. V. Baranovsky // Bulletin of the Orenburg State Agrarian University. - 2020. - No. 1. - p. 28-33.
[6] Bortnik, T.Yu. State of soil fertility and productivity of grain crops in the michurin shpk, vavozh district, udmurt republic / T.Yu. Bortnik, A.S. Bashkov, V.A. Kapeev, B.B. Borisov // Bulletin of the Izhevsk State Agricultural Academy. - 2019. - No. 3. - P. 24-35. - ISSN 1817-5457. - Text: electronic // Lan: electronic library system. — URL: https://e.lanbook.com/journal/issue/311539 (date of the application: 01.05.2020).
[7] Vavilov, P.P. Crop production / P.P. Vavilov, V.V. Gritsenko, V.S. Kuznetsov. - M.: Kolos, 1979 .-- 524 p.
[8] Glinushkin A.P., Ovsyankina A.V., Kiseleva M.I., Kolomiets T.M. Distribution of fungi of the genus Fusarium link. on grain crops // Russian agricultural science. 2018.No. 2.P. 19-25.
[9] Achievements of science and technology of the agro-industrial complex. 2017.Vol. 31.No. 2.P. 39-44.
[10] Dubachinskaya, N.N. Efficiency of safe production of grain products under different environmental conditions / N.N. Dubachinskaya, N.N. Dubachinskaya // Bulletin of the Orenburg State Agrarian University. - 2016. - No. 4. - p. 195-198.
[11] Kislov A.V., Glinushkin A.P., Kascheev A.V. Agroecological foundations for increasing the sustainability of agriculture in the steppe zone // Achievements of science and technology of the agro-industrial complex. 2018.Vol. 32.No. 7.P. 9-13.
[12] Kislov A.V., Glinushkin A.P., Kascheev A.V., Sudarenkov G.V. Ecologization of crop rotations and the biological system of reproduction of soil fertility in the steppe zone of the Southern Urals // Agriculture. 2018. No. 6. P. 6-10.
[13] Konovalova, N.Yu. The influence of the timing of harvesting grain crops on the productivity and quality of the resulting grain fodder in the European North of Russia / N.Yu. Konovalova, S.S. Konovalov // Dairy Bulletin. - 2018. - No. 1. - P. 46-56.
[14] Matorin D.N., Timofeev N.P., Glinushkin A.P., Bratkovskaya L.B., Zayadan B.K. Investigation
of the effect of fungal infection of Bipolaris sorokiniana on light reactions of wheat photosynthesis using the fluorescent method // Moscow University Bulletin. Series 16: Biology. 2018. Vol. 73. No. 4. P. 247-253.

[15] Mitrofanov, D.V. Influence of air temperature and soil moisture on the productivity of grain crops in four-field crop rotations at the soil protection station of Orenburg Zauralie // D.V. Mitrofanov // Bulletin of the Orenburg State Agrarian University. - 2019. - No. 5. - P. 36-40.

[16] Mikhailova, Z.I. Influence of tillage methods on the productivity of grain crops / Z.I. Mikhailova, A.A. Mikhailov, O.V. Yakulenko // Bulletin of the Krasnoyarsk State Agrarian University. - 2016. - No. 4. - P. 10-15.

[17] Muratov, M.R. Correlation of productivity of grain and leguminous crops from agrochemical parameters of soils and weather conditions / M.R. Muratov, M.Yu. Gilyazov // Bulletin of Kazan State Agrarian University. - 2015. - No. 2. - p. 128-135.

[18] Nalyukhin A.N., Khaimitova S.M., Glinushkin A.P., Avdeev Yu.M., Snetilova V.S., Laktionov Yu.V., Surov V.V., Siluyanova O.V., Belozerov D.A. Changes in the metagenome of the prokaryotic community as an indicator of the fertility of arable sod-podzolic soils with the use of fertilizers // Pochvovedenie. 2018. No. 3. P. 331-337.

[19] Ovsyankina A.V., Kiseleva M.I., Glinushkin A.P. Species composition of fungi from the genus Fusarium on crops of spring barley in the central part of Russia in 2015-2017 // Russian agricultural science. 2018. No. 5. P. 41-46.

[20] Piletsky, I.V. Yield of grain and grain palimium crops in planning of the feed base of livestock belarusian landscape / I.V. Piletsky, A.I. Piletsky // Scientific notes of the educational institution "Vitebsk Order" Badge of Honor "State Academy of Veterinary Medicine". - 2013. - No. 2-1. - p. 338-342.

[21] Plotnikov, A.M. Agrochemical properties of leached chernoze and productivity of grain crops under the influence of fertilizers and chemical Ameliorants in the Trans-Ural region. Plotnikov // Bulletin of the Kurgan State Agricultural Academy. - 2018. - No. 4. - P. 30-35.

[22] Resource potential of field crops of the Orenburg region (brief characteristics of varieties and hybrids): teaching aid / compiled by GF Yartsev [and others]. - Orenburg: Orenburg GAU, 2019. -- 106 p.

[23] Semenov A.M., Glinushkin A.P., Sokolov M.S. Soil ecosystem health: from a fundamental setting to practical solutions // Izvestiya Timiryazevskaya Agricultural Academy. 2019. No. 1.P. 5-18.

[24] Sidorenko, O. V. Natural-climatic and economic factors of increasing yield of grain crops in orlovsk region / O.V. Sidorenko, N.A. Yakovleva // Bulletin of Agrarian Science. - 2017. - No. 5. - p. 101-106.

[25] Sokolov M.S., Glinushkin A.P. Biotic regulation is a real factor in the dearidization of the agrosphere // Bulletin of the Oryol State Agrarian University. 2017. No. 3 (66). P. 40-46.

[26] Sokolov M.S., Glinushkin A.P., Spiridonov Yu.Ya., Toropova E.Yu., Filipchuk O.D. Technological features of soil-protective resource-saving agriculture (in the development of the FAO concept) // Agrochemistry. 2019. No. 5. P. 3-20.

[27] Sokolov M.S., Sanin S.S., Dolzhenko V.I., Spiridonov Yu.Ya., Glinushkin A.P., Karakotov S.D., Nadyka V.D. The concept of fundamental applied research on plant protection and harvest // Agrochemistry. 2017. No. 4. P. 3-9.

[28] Sokolov M.S., Semenov A.M., Spiridonov Yu.Ya., Toropova E.Yu., Glinushkin A.P. Healthy soil is a condition for the sustainability and development of argon and sociospheres (problem-analytical review) // Izvestia of the Russian Academy of Sciences. Biological series. 2020. No. 1. P. 12-21.

[29] Sokolov M.S., Semenov A.M., Spiridonov Yu.Ya., Toropova E.Yu., Glinushkin A.P. Healthy soil is a condition for sustainability and development of agro-sociospheres // Problems of Materials Science. 2020. No. 1. P. 12.