Evaluation of spring wheat in the context of grain production in the Tyumen region and characterization of the ecologic resistance of its varieties in attaining food security

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Abstract. Grain production plays a leading role in Russia's food security. The indicators of grain production in the Tyumen region for 2014-2018 and the characterization of spring wheat varieties by yield and adaptability parameters for 2017-2019 are presented. The material of the study was the data of the Department of Federal Service of State Statistics of the Tyumen region on the production of cereals and the results of variety testing of spring wheat in the conditions of the northern forest steppe zone of the Tyumen region. The realization of yield potential of the varieties was determined by E.D. Nettevich's method, the scope of indicators of grain production and productivity of varieties was found according to V.A. Zykin, the index of environmental conditions and ecological plasticity of varieties – according to S.A. Eberhart, W.A. Russell, and the ecological resistance – according to D. Lewis. The average yield of cereals and legumes was 2.06 t/ha and that of spring wheat – 1.95 t/ha. The variety Tyumenskaya 29 was characterized by the highest average yield (4.67 t/ha). Depending on the variety the realization of yield potential ranged from 77.0% (Lutescens 70) to 86.6% (Scent 3). According to the responsiveness to the change in conditions, three groups of varieties were noted: strongly responsive to the change of conditions – Ikar, Tyumenskaya 29; plastic – Lutescens 70, Scent 3, Aviada; weak responsive to changing conditions – Chernyava 13, Omskaya 36. By their ecologic resistance the varieties Scent 3 and Tyumenskaya 29 were the best. According to the results of the complex assessment of varieties, the variety Tyumenskaya 29 was deemed the best.

1. Introduction

The food security is the basis of a country's economic security. Within the framework of the Doctrine of the Food Security of the Russian Federation, the State Program for Agricultural Development has been developed and is being implemented. It provides for the comprehensive development of all sectors of the agro-industrial complex taking into account Russia's accession to the World Trade Organization [1].

One of the most important sectors of agricultural production of the Russian Federation is the grain farming, which accounts for more than 9% of the gross product of the national food industry, and the grain production acts as an indicator of agriculture culture and agricultural development [2, 3].

The various factors and conditions are influenced on the formation of stable grain production, primarily natural-climatic ones [4]. About 65-70% of losses in crop production are due to the unfavorable weather and climatic conditions according to studies [5].
The spring wheat is the main grain culture of Western Siberia. Increasing its productivity remains one of the main tasks of crop production [6].

The variety plays leading role in increasing of grain production. From 50 to 70% of the increase of yield in Russia happens due to new varieties [7].

The yield potential of modern varieties of spring wheat is quite high – more than 6.0 t/ha. However, the level of realization of their genetic potential is relatively low and in various agroclimatic zones of Western Siberia (within 1.5 t/ha) as a consequence of low resistance to a complex of biotic and abiotic stress factors [8].

The introduction of varieties with high yields but low resistance to the unfavorable environmental conditions leads to little yield growth and considerable variability. Only high adaptability of the varieties can ensure crop stability under different environmental conditions. The adaptive variety is ecologically plastic, adapted to all external factors of the environment. The integrated criterion of this variety is its yield level [6.9-14].

The purpose of the study is the estimation of grain production in the Tyumen region and characterization of the spring wheat varieties allowed to use by their productivity and adaptability parameters.

2. Materials and methods
The material of the study was the data of the Department of the Federal Service of State Statistics of the Tyumen Region on the production of cereals for 2014-2018 [15] and the data of the productivity of mid-season varieties of spring wheat according to the results of their test for 2017-2019 at Omutinsky and Ishimsky State Plots (III zone, northern forest steppe) [16].

The actualization of yield potential of the spring wheat varieties was determined according to E.D. Nettevich [17], and the range of indicators of grain production and productivity of varieties – according to V.A. Zykin's method [18]. The index of environmental conditions and the ecological plasticity of varieties (coefficient of regression) and their ecological stability were determined respectively according to S.A.Eberhart, W.A.Russell [19] and D. Lewis [20] in the variant of A.A. Goncharenko [21].

3. Results and discussion
The area of grain and leguminous crops in the Tyumen region amounted to 689.4 thousand hectares in 2014-2018 with a maximum value of 698.5 thousand hectares in 2014 (table 1).

Table 1. The indicators of the production and the share of spring wheat in the production of grain and leguminous crops in the Tyumen region

| Year | Grain and leguminous crops – in all | Spring wheat |
|------|------------------------------------|--------------|
|      | area of sowing, thousand hectares  | yield, t/ha  |
|      |                                   | gross yield, thousand tons | area of sowing, thousand hectares | yield, t/ha | gross yield, thousand tons |
| 2014 | 698.5                              | 2.16         | 1487.9 | 406.7 | 58.2 | 1.97 | 796.7 | 53.5 |
| 2015 | 693.1                              | 1.93         | 1338.5 | 388.8 | 56.1 | 1.89 | 741.5 | 55.4 |
| 2016 | 696.2                              | 1.88         | 1288.2 | 425.4 | 61.1 | 1.75 | 740.6 | 57.5 |
| 2017 | 686.8                              | 2.33         | 1587.8 | 409.0 | 59.6 | 2.22 | 917.1 | 57.8 |
| 2018 | 672.2                              | 2.00         | 1341.2 | 384.8 | 57.2 | 1.93 | 753.0 | 56.1 |
| Average(х) | 689.4                          | 2.06         | 1408.7 | 402.9 | 58.4 | 1.95 | 789.8 | 56.1 |
| Scope (d%) | 3.8                              | 19.3         | 18.9   | 9.5   | -    | 21.2 | 19.2   | -    |

A decrease in the area of grain sowing was revealed in the time dynamics, in particular by 26.3 thousand hectares in 2018 compared to 2014. This is connected with the expansion of the area under
other crops, as well as the non-use of a part of low-productive land. The scope of sown area is insignificant and amounted to 3.8% on average for the analyzed period.

The average yield of cereals and legumes for 2014-2018 was 2.06 t/ha, and a gross yield for the same period amounted to 1408.7 thousand tons. The maximum value of these indicators was noted in 2017 was 2.33 tons/ha and 1587.8 thousand tons respectively. In the time dynamics, there was no significant change in yield and gross crop, and their scope is significant, amounting to 19.3 and 18.9% respectively.

The area of sowing of spring wheat on average 2014-2018 amounted to 402.9 thousand hectares, with a maximum value of 425.4 thousand hectares in 2016 (table 1). The share of the area under spring wheat from the area of cereals and legumes varied from 56.1% in 2015 to 61.1% in 2016 and its share was averaged 58.4%. This indicates its leading role in the grain production in the Tyumen region. In the time dynamics there was a slight decrease of the area of sowing of spring wheat, and its scope was characterized by a slight value – 9.5%.

The yield of spring wheat was averaged 1.95 tons/ha in 2014-2018, and the gross yield was 789.8 thousand tons (table 1). The maximum values of these parameters were noted in 2017 – 2.22 tons/ha and 917.1 thousand tons respectively. The share of spring wheat in the gross yield of cereals and legumes amounted to 56.1% on average, with fluctuations in the years of the analyzed period from 53.5% (2014) to 57.8% (2017). This once again emphasizes its leading role in the grain production and solving the problem of food security.

In the time dynamics, there is no significant change in yield and the gross yield, except for the indicators of 2017. This lack of progress is primarily due to the insufficient level of certain components of agriculture culture (doses of fertilizers, the use of means of protection against diseases and pests, compliance of crop rotations and elements of crop cultivation technology, etc.).

The main area of the grain crops sowing, as well as spring wheat is concentrated in the northern forest steppe zone of the Tyumen region. The mid-season varieties of spring wheat, as higher-yield, predominate in the total area of its sowing. We have assessed the yield and the adaptive potential of varieties of this group of ripeness. In order to increase the reliability of this estimate the parameters were calculated from data was obtained in six environments: 3 years x 2 State Testing Plots = 6 environments.

The environmental conditions during the test years of the varieties were characterized as contrasting. They were the most unfavorable in terms of conditions index in 2017 at Omutinsky State Testing Plot (Ij = -0.95), and the most favorable – in 2019 at Ishimsky State Testing Plot (Ij = 0.99) (table 2).

We have identified a high yield potential among the allowed-for-use varieties. In the most unfavorable agroclimatic conditions of 2017, Tyumenskaya 29 was the best variety (3.76 t/ha), and in the most favorable conditions of 2019, the variety Aviada (5.87 t/ha) prevailed. The same varieties had the highest average yield for 2014-2018 – 4.67 and 4.65 t/ha respectively (table 2). An increase of the level of minimum, maximum and average yields was revealed in the time dynamics of allowed-for-use varieties. This indicates of the effective work of the selective institutions in the region to produce and introduce highly productive varieties into production. Thus, the yield of the variety Tyumenskaya 29 (allowed for use in 2013) in share terms amounted to 111.7% compared to the variety Lutescens 70 (allowed for use in 1993).

Actualization of the genetic potential of varieties is one of the leading indicators in their assessment, the value of which is formed in the system of the interaction between the genotype and the environment. According to our studies, the actualization of the yield potential of the mid-season varieties in the northern forest-steppe zone is relatively low, assuming that the varieties were tested against the high agricultural background, that is, after fallow. The varieties Scent 3 (86.6%) and Tyumenskaya 29 (84.4%) were characterized by the highest yield potential actualization (table 2). In order to increase this indicator, the introduction of the varieties with a high level of adaptability into production plays an important role, as well as compliance with the technology of their cultivation based on biological characteristics, i.e. compliance with variety agriculture. In the time dynamics of the allowed varieties, a slight increase in this indicator has been detected.
The yield scope is significant and depending on the variety was from 32.0% (Tyumenskaya 29) to 38.8% (Lutescens 70). This indicates, first of all, of the insufficient resistance of varieties to unfavorable environmental conditions (Table 2).

**Table 2.** The yield, the actualization of its potential and the adaptability of spring wheat varieties, 2017-2019. (III zone, northern forest steppe, 3 years x 2 State Testing Plots = 6 environments)

| Variety         | Year of allowed for use | Yield, t/ha | Average yield | Realization of yield potential, % | Scope of yield (d%) | Plasticity (coefficient of regression, b) | Ecological stability (SF) |
|-----------------|-------------------------|-------------|---------------|----------------------------------|---------------------|------------------------------------------|---------------------------|
| Lutescens 70    | 1993                    | 3.32        | 5.43          | 4.18                             | 100.0               | 77.0                                     | 0.98                      | 1.64                     |
| Chernyava 13    | 2000                    | 3.49        | 5.30          | 4.36                             | 104.3               | 82.3                                     | 0.87                      | 1.52                     |
| Ikar            | 2001                    | 3.46        | 5.54          | 4.50                             | 107.6               | 81.2                                     | 1.12                      | 1.60                     |
| Scent 3         | 2003                    | 3.39        | 5.00          | 4.33                             | 103.6               | 86.6                                     | 0.91                      | 1.47                     |
| Aviada          | 2004                    | 3.65        | 5.87          | 4.65                             | 111.2               | 79.2                                     | 1.10                      | 1.61                     |
| Omskaya 36      | 2008                    | 3.32        | 5.26          | 4.31                             | 103.1               | 81.9                                     | 0.83                      | 1.58                     |
| Tyumenskaya 29  | 2013                    | 3.76        | 5.53          | 4.67                             | 111.7               | 84.4                                     | 1.21                      | 1.47                     |
| SSD05           |                         |             |               |                                  |                     |                                          |                           | 0.25                     |
| Index of conditions of the environment (Ij) | - | 0.99 | | | | | |

The method of S.A.Eberhart, W.A.Russell [19] for determining the ecological plasticity of varieties involves the calculation of the regression coefficient, which characterizes the responsiveness of varieties to changing conditions. By the value of this indicator, we have selected three groups of varieties: with strong responsiveness (b > 1), plastic (b equal or close to one) and weak responsiveness (b < 1). The first group included the varieties Ikar (b = 1.12) and Tyumenskaya 29 (b = 1.21) (table 2). These are varieties of intensive type which will have the greatest effect when they will be cultivated on intensive agricultural background. However, they are less adaptable to unfavorable environmental conditions, and their adaptation is specific.

The second group included varieties Lutescens 70, Scent 3 and Aviada. In these varieties, the change in yield fully corresponds to the change in growing conditions.

The third group includes varieties Chernyava 13 (b = 0.87) and Omskaya 36 (b = 0.83). These are semi-intensive varieties, which it is desirable to place when they are cultivated in fields with relatively low agrophone, where they will have the greatest effect at minimum costs.

The ecological stability of all varieties studied is low (SF > 1). This indicates of phenotypic instability of the genotype, which is confirmed by the size of the yield scope of the varieties. Depending on the variety, this indicator ranged from 1.47 (Scent 3, Tyumenskaya 29) to 1.64 (Lutescens 70) (Table 2).

**4. Conclusion**

The studies revealed a decrease in the area of the grain and leguminous crops for the period from 2014 to 2018 and no significant change of their yield and the gross crop. The spring wheat is the main culture in the grain production in the region, both in terms of the sowing area and the gross crop. The allowed-
for-use wheat varieties are characterized by high yield potential, but little potential actualization, considerable yield and low ecologic resistance. It adversely affects the stability of the grain production. According to the responsiveness of varieties to changing conditions, three groups have been identified, which should be taken into account when the studied varieties are cultivated in production in order to improve yield and stability.

References
[1] Onishchenko K N and Onishchenko S K 2016 Cyclical Changes in yield of grain crop in EAEU countries Agrarian Russia 12 2–6
[2] Marchenko A V and Trotsenko V M 2013 Efficiency of grain production in the Perm Kray Agrarian Russia 11 30–32
[3] Khomyakov D M 2011 Grain production in Russia and nature management Agrochemical Herald 1 6–9
[4] Alabushev A V 2011 Stabilization of grain production in climate changing conditions Grain economy of Russia 4 8–13
[5] Eroshenko L M, Romakhin M M, Eroshenko N A, Levakova O V, Dedushev I A and Naumova V V 2018 The use of the method of adaptability estimation, genotype stability and differential ability of the environment in spring barley breeding to improve grain quality Grain economy of Russia 6(60) 55–59
[6] Ageeva E V, Likhenco I E and Sovetov V V 2018 Evaluation of Environmental plasticity of spring soft wheat samples from the nursery of the Kazakhstan-Siberian network SIMMYT Achievements of science and technology of Agro-Industrial Complex 32(11) 26–29
[7] Novokhatin V V 2018 Scientific substantiation of primary and elite seed-growing cereals Achievements of science and technology of Agro-Industrial Complex 32(9) 40–47
[8] Shamanin B P and Petukhovsky S L 2012 Development of parent material for breeding of spring soft wheat in Western Siberia Siberian Herald of Agricultural Science 6 10–16
[9] Goncharenko A 2005 On adaptavity and ecological resistance of grain crop varieties Herald of the Russian Academy of Agricultural Sciences 6 49–53
[10] Huang M, Mheni N, Brown-Guedira G et al 2018 Genetic analysis of heading date in winter and spring wheat Euphytica 214(8) 128
[11] Ayalneh T, Letta T and Abinasa M 2013 Assessment of stability, adaptability and yield performance of bread wheat (Triticum aestivum L.) cultivars in South Eastern Ethiopia Plant Breeding and seed science 67(1) 3–11
[12] Sapega V A 2019 Genotype-environment interaction, productivity and adaptive potential of spring wheat varieties Russian agricultural science 3 10–15
[13] Zhuchenko A 2004 Possibilities of creating plant varieties and hybrids taking into account climate change, in: Adaptive breeding strategy for field crops in connection with global climate change (Saratov: Sputnik) pp 10–16
[14] Alabushev A V 2013 Adaptive potential of varieties of cereals crops Legumes and cereals 2(6) 47–51
[15] 2019 Tyumen Region in Figures: Short Statistical Collection (Department of the Federal Service of State Statistics of the Tyumen Region, Khanty-Mansisk Autonomous District - Ugra and Yamalo-Nenets Autonomous District) 1 203
[16] Vydrin V V and Fedoruk T K 2019 Variety zoning of agricultural crops and results of variety testing in the Tyumen region in 2019 (Tyumen: Tyumen publishing house)
[17] Nettevich E D 2001 Yielding potential of the varieties spring wheats and barley which recommendation for cultivated in the Central region of Russia and its realization in conditions of manufacture Reports of Russian Academy of Agricultural Sciences 3 3–6
[18] Zykin V A, Belan I A, Rosseev V M and Pashkov S V 2000 Breeding of spring wheat on adaptability: results and prospects Reports of Russian Academy of Agricultural Sciences 2 5–7
[19] Eberhart S A and Russell W A 1966 Stability parameters for comparing varieties *Crop. Sci.* 6(1) 36–40
[20] Lewis D G 1954 Gene-environment interaction: A relation between dominance, heterosis, phenotypic stability and variability *Heredity* 8 333–356
[21] Goncharenko A A, Makarov A V, Yermakov S A, Semenova T V and Tochilin V N 2015 Estimation of ecological stability and plasticity of inbred lines of winter rye *Reports of Russian Academy of Agricultural Sciences* 1-2 3–9