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Assessment of spring triticale varieties and lines for their adaptability in the middle Volga region forest-steppe conditions

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Abstract

This paper presents the research results on the evaluation of spring triticale plants. An important criterion for ensuring the planned yield is the stability shown by a variety, i.e. its ability to produce high yields under different environmental conditions. When the genotype has a high interaction degree with the environment, the yield varies dramatically under different growing conditions. Such varieties are only reliable for yield under specific conditions.

When plants are exposed to conditions that are unusual for them, a stress situation is created which determines the response rate for the individual genotype in the population. The research revealed that most of the studied spring triticale variety samples were resistant to extreme growth conditions and had high productivity.

Keywords: spring triticale, variety samples, testing, resistance, yield

Introduction

Ensuring the food raw material and foodstuff safety is a factor determining human health and the gene pool preservation. One of the ways to solve this problem is to use the adaptive potential of plants, and their resistance to edaphic environmental factors. The correct choice of a variety for a specific zone and its soil and climatic conditions is of paramount importance for obtaining high grain yields with high technological qualities.

Triticale is extensively studied in many countries of the world, where many varieties have been developed with different economic uses. The area of triticale in Russia grows steadily every year. The developed triticale varieties and lines in Russia have considerable diversity with high yield potential in grain and green mass. If it is a fodder variety, it is characterized by a high green mass yield, a higher share of leaves in the mass structure, a lower tissue lignification rate, a longer period of use, and a high nutritional value of raw material [2, 3].

Triticale varieties used for food purposes have high protein and lysine content in grain, drought resistance in combination with resistance to diseases and pests, high productivity and good adaptability to various conditions, including extreme ones [1, 6, 7].

Due to these economically valuable features, triticale is becoming increasingly important in the grain and fodder balance of the country. Modern triticale varieties occupy a wide niche between rye and wheat [4, 5].

According to the complex of environmental factors limiting the growth and development of triticale in different agro-ecological niches, it is expected to develop varieties that can increase the grain and protein yield per unit area. As a result, it is necessary to carry out a comprehensive study and include the world triticale diversity in the breeding process as a starting material, which, as N. I. Vavilov pointed out, determines the success of any crop's selection [9].

The emergence of spring triticale increases the adaptive crop production capacity in the Middle Volga region and improves the environment conditions by reducing the pesticide load. Under conditions of ameliorants deficit and increase of soil acidity, this crop will help to stabilize yields. Spring triticale cultivation will complement the set of early spring crops, increase the yield, collection of valuable protein, reduce the fungicide cost, increase biodiversity and stability of agroecosystems [8, 10-12].

The aim of our work is evaluation and selection of variety samples from world spring triticale collection by the complex of economically valuable characters for their further inclusion in selection of new highly productive varieties.

Materials and Methods

In connection with the set aim, studying the spring triticale's gene pool in the Middle Volga region forest-steppe conditions for their further use in breeding and production practice is an actual measure.

The research material was varieties and lines of spring triticale of different origin. Experimental work was carried out in 2015-2017 in the Bessonovsky district of Penza region. The Bessonovsky District's territory is part of the forest-steppe zone of the Middle Russian soil-geographical province, being a leached chernozem subzone. The area is characterized by sufficient and partly moderate moisture. Tillage was used as a precursor. Seed rate was 5.0 mln germinated seeds per 1 ha at optimum dates. The standard in the test was an Ukro variety. When developing the experiment scheme, observations and analysis of spring triticale plants, we followed the VIR methods [13], field experiment methods [14], and also state variety testing methods for agricultural crops [15-19].

Results and Discussion

The field germination of seeds of any crop is significantly affected by weather conditions during their germination; the survival and safety of plants are affected by weather conditions for 35%, by the agrotechnics level and its methods for 35%, and by biological characteristics of the crop and variety, namely, by level of bushiness and density of productive stems, for 30%.

Weather conditions during the growing season of spring triticale plants differed sharply by years of research. Weather conditions in 2015 were characterized as warm with insufficient moisture. The precipitation amount during the crop growing season was 148.8 mm, while the average perennial amount was 215.0 mm, which was 30.8% below the norm. The sum of average daily temperatures during the growing season was 229.3 °C, which was 19.1 °C higher than the long-term average.

The average air temperature was 17.4 °C in May, which was 3.3 °C higher than the long-term average. Precipitation was 58.5 mm, and it was 20.5 mm higher than the long-term average. Temperatures were 17.3 °C in June, 1.1 °C below normal. Precipitation amounted to 51.4 mm, 8.6 mm below the long-term average. Precipitation was 5.2 mm instead of the normal 64 mm, and temperatures were 1.0 °C higher than normal. In August, the air temperature was 1.2 °C higher than the norm and precipitation was 19.3 mm below the norm.

In general, the 2015 growing season had weather periods that limited the realisation of the crop's potential productivity.

In 2016, weather conditions were characterised as warm with insufficient moisture. The sum of active temperatures exceeded the long-term average by 4.4 ºC. The precipitation total during the growing season was 176.7 mm, which was 38.3 mm below the long-term average.

During the sowing period and seed germination in May, the average daily air temperature was 14.9 °C, which was close to the annual average (14.1 °C). In June, the air temperature was 2.9 °C higher than the long-term average. Mean daily air temperatures in July were close to the long-term average. At the same time, the amount of precipitation was 22.1% and 30.9% higher than the normal level. However, in August, during the grain ripening period, the precipitation amount was significantly less than the annual average of 7.5 mm, 8.5% below the norm.

Weather conditions in 2017 were characterised as warm, but with insufficient moisture. The sum of active temperatures exceeded the long-term average by 8%. Total rainfall during the growing season was 171 mm, 34.6 mm below the long-term average.

Plant growth is an integral indicator of their adaptation to external environmental conditions. It is related to the characteristics of the variety such as early maturity, productivity and others. The life cycle of spring triticale plants is divided into different phases, in each of which certain changes in their development occur. The degrees of development for their organs in each phase vary, as well as the time of the phase's passage, depending on the sample's genotype and the environment conditions [6, 7].

As a result of the studies, significant differences in the growing season duration in the triticale samples under study have been revealed. The variability amplitudes in the growing season duration depended on the growing conditions. Differences in the phenological phase onset of the tested spring triticale samples were observed from the beginning of plant sprouting. Sprouting in varieties under study appeared on 6-12th days. This phase was 3-6 days later in foreign samples compared to domestic ones.

Spring triticale finishes its stem elongation period faster than spring wheat makes, and heading, flowering, and grain filling of the former are longer. Most of the tested samples behaved as medium-ripening ones in terms of the vegetation period duration. The vegetation period duration for its samples ranged from 78 to 128 days and their ripening was prolonged by 5 to 14 days. Late maturation was observed in samples of foreign selection. The growing season duration was due to the long phase between ear formation and waxing ripeness.

High field germination for grain crops is one of the most important indicators for the formation of optimum stem structure. The density of the standing plants before harvesting indicates the total yield of the spring triticale varieties tested under specific growing conditions. The research data show that the studied spring triticale varieties on the average according to the experiment are characterized by the number of productive stems from 367 to 432 pieces per 1m², with 430 pieces available for the variety Ukro. The highest completeness of shoots in the experiment with samples of foreign selection was characterized by the Canadian variety Alta - 67.4%.

Field germination of seeds of tested spring triticale varieties in 2015 was at 54.3-65.2% with 65.8% for the standard variety Ukro. In 2016, it was between 57.3% and 66.3%, with 67.1% for the Ukro variety. In 2017, the field seed germination of spring triticale varieties was 56.2-68.5%, with 66.7% for the Ukro variety. The main reason for the decline in germination of spring triticale varieties was germination of grain in ears. As grains dried out, the germs died off that had begun to grow, resulting in reduced germination of the seeds.

Analysis of the research data shows that the samples PRAG-C 316, Armino 15 - 1, Ac Frank, Saur, Haykar had germination percentage on average for the experiment 1,8 - 13,8% higher than the standard value. The varieties Castro Verde, Lana, SATG 20 - 3, FAB Dwg rue "Good seed", Zaozerye had germination percentage significantly below the standard by 5.7 - 21.8%.

The survival rate of the tested triticale plants was on average 1.2-11.6% below the standard due to the lower viability of triticale plants and insufficient ecological plasticity of some of the varieties studied.

The spring triticale plants' safety of tested varieties in the years of research ranged from 67.4 to 83.3%, with 77.2% for the variety Ukro. The greatest safety in the experiment was characteristic for Zado, Saur, Khaykar, and Zaozerye, ranging from 82.6 to 83.3%, which was 4.9 to 6.1% higher than the variety Ukro's safety. The lowest retention rate in the years of the study was characteristic for the variety AC Alta - 57.4%.

The highest percentage of surviving plants in 2015 was characteristic for FAB Dwf rue 'Good seed' (96.8%) with 96.1% for the Ukro standard. In 2016, the Polish variety Zado had a high survival rate of 82.7%, 9.5% higher than the Ukro variety. In 2017, the same variety showed high plant survival to harvest - 84.0%, which was 2.7% higher than the Ukro variety. Basically, the low plant survival to harvest of the studied spring triticale foreign-selected varieties is explained by insufficient ecological plasticity.

The hexaploid triticale forms are characterized by different types of inheritance characteristic for plant height: dominance of high-growth plants, dominance of stunting plants, and intermediate inheritance. Stunting of hexaploid triticale forms is controlled by alleles of one or two genes. The reduction of the plant height in hexaploid forms of triticale was practically not accompanied with deterioration in productivity and grain quality, indicating the possibility of an effective selection and creation of new source material for the selection of intensive varieties. Lodging leads to a sharp decrease in photosynthesis and other biochemical processes due to shading, increased damage by diseases and injuries at harvesting, which in turn leads to a decrease in the number of conceived grains in the ear, reduced weight of 1000 seeds, and deterioration of technological and seed qualities. Grain losses from lodging in the cultural signs in different regions of the country fluctuate up to 50%, and in some years up to 80% [6].

The results of our research show that in terms of plant height, most of the tested varieties were on average 1-15 cm below the standard variety Ukro (84 cm).

The plant height formation was significantly influenced by weather conditions. Over the years of the triticale samples study, there was a significant variation in plant height from 80.1 cm in the PRAG-C 316 to 104.3 cm in the variety CATG 20 - 3.

The productive bushiness influences the formation of grain mass per plant and the number of developed spikelets. The spring triticale bushiness under our conditions depending on the sample varied from 1.9 to 3.6. Relatively high bushiness was characteristic for triticale Jago - 3.6; Castro Verde - 3.2; PrAG - C - 3.0.

A significantly higher value of total bushiness compared to the standard variety was observed for Ac Frank, Saur, Haikar.

The number of productive stems per unit area and the weight of grain from the main ear are in close relationship with other elements of the yield structure. Grain weight from the main ear depends on the weight of 1000 grains and the number of grains in an ear.

The tested triticale plants exceeded the standard Ukro in the number of ears in most cases. The varieties Jago with 16.9 spikelets and Castro Verde with 19.5 spikelets were below the standard.

Availability of multiple spikelets was characteristic for FAB Dwf rue "Good seed", Ac Frank, SATG 20-3. They had 23,8; 22,5; 22,2 spikelets, respectively, with 21,4 spikelets for Ukro.

Particular attention should be paid to the grains/ear rate of a main ear and fertility of middle ears. There is a great potential for increasing the grains/ear rate in triticale, since their large ears sometimes contain up to 250-300 well-developed flowers, of which approximately 30-50% remain sterile.

The studied varieties and lines of spring triticale formed on average 25.5 grains in main ears of the variety PRAH-C 316, up to 28 grains in main ears of the variety Zado, with 31 grains in main ears of the variety Ukro. None of the tested varieties of spring triticale in 2015-2017 exceeded the standard variety Ukro by the number of grains in the main ear.

A significant decrease in the grains/ear rate for a main ear relative to the standard was shown by FAB Dwf rue "Good seed", Zaozerye.

Ecological factors have a great influence on grain size. Triticale grains of the forage type have a smaller grain size, while triticale grains of the grain type are more likely to form larger grains. There is a correlation between grain size and grain wrinkling: small grains perform better than large ones.

In 2015-2017, grain weight per main ear in the studied variety of spring triticale was 0.13-0.21 g lower than the grain weight per main ear in the standard variety Ukro. The standard grain weight per main ear was 1.38 g in the experiment. The low grain weight per main ear was characteristic for the variety AC Alta - 1.17 g. The variety Zado was characterized with high weight of a main ear of the foreign selection in the experiment - 1.25 g.

Most of the triticale samples studied were characterized by large grains. The average weight of 1000 grains averaged 42.1 to 49.8 g in the experiment, compared with 41.2 g in the standard variety Ukro. Among the triticale varieties examined, the large grain size was characteristic for the samples from Mexico, Voronezh Region, and Leningrad Region, where the weight of 1000 grains exceeded the standard by 8.9; 7.8; 6.9 g, respectively.

The weight of 1000 grains of the tested spring triticale varieties varied differently during the years of study. It was between 34.9-40.6 g in 2015 and 39.7-41.4 g in 2016, with 41.8 g and 42.8 g for the standard variety Ukro respectively in the years of study. In 2017, the weight of 1000 grains in these varieties was at 38.5-45.7 g with 49.3 g in the standard variety Ukro.

On average for the experiment, the highest 1000 grain weight was characterized by the variety Zado - 43.0 g, the lowest 1000 grain weight was determined by the variety AC Alta - 39.1 g.

The triticale crop is prone to brown rust, but to a lesser extent than rye and wheat. It is affected by wheat races and is immune to rye races. The hexaploid forms are more resistant to brown rust than the octoploid forms, some of which can approach wheat in terms of damage. Depending on their origin, triticale varieties have different numbers of dominant and recessive genes for resistance to brown rust. Consequently, resistance is inherited differently.

In 2015-2017, the tested spring triticale varieties showed varying resistance to rust disease with a range from immunity to 25% damage.

Yield is the most important indicator by which samples are evaluated. An important criterion for achieving the planned yield is the stability of the variety, its ability to produce high yields under different environmental conditions. When the interaction of a variety's genotype with its environment is high, yield varies greatly under different growing conditions. Such varieties are only reliable for yield under specific conditions.

The growing conditions of the entire period under consideration did not allow spring triticale to realize its productivity potential. The main reason for the yield shortfall was temporary soil moisture deficits, which were observed in all years.

Compared to the standard in 2015, the triticale’s productivity varied widely depending on the genotype: from 3.40 t for Castro Verde to 4.7 t for FAB Dwf rue "Good seed". The Haikar variety showed a high yield of 3.6 t/ha, compared with 3.1 t/ha for the standard.

In 2016, none of the tested varieties exceeded the standard variety Ukro in yields compared with it. Yields of the tested samples ranged from 1.9 to 2.3 t/ha, with 2.4 t/ha for the Ukro variety.

In 2017, the yields of the studied spring triticale varieties were at 1.7-2.0 t/ha, with 2.6 t/ha for the standard. The low yield of spring triticale varieties of foreign selection is explained by the less fulfilled grain.

The average grain unit of triticale varieties in the experiment was 696 g/l. The highest grain unit was 784 g/l shown by the variety Saur, the lowest was 642 g/l for the variety AC Alta.

Conclusions

Under the conditions of the Middle Volga region and especially of the Penza region, spring triticale is a poorly distributed and poorly studied crop.

As a research result, varietal specificity of spring triticale in terms of productivity was revealed.

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