Triticale potential model in the conditions of the Amur region

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Abstract. The need for research is due to the growing demands of the region's animal husbandry in fodder grain. The goal is to establish the average and maximum values of the main economic indicators of triticale varieties in various zones of the region. The experiments were carried out in 2012–2016 on the fields of the zonal State Variety Testing Stations of the Amur Region. Soils are typical of zones. Meteorological conditions during the growing season of triticale are different. Triticale varieties were studied: Karmen St, Grebeshok, Rovnya, Ukro and Yarilo. Late-ripening varieties in all zones of the region form a high stem. Location of triticale varieties by grain threshing Karmen> Rovnya> Grebeshok and Yarilo> Ukro. The largest mass of 1000 grains - 53.6 g and a yield of 5.36 t/ha is formed by the Karmen variety in the south of the region. Yarilo gives the highest yield in the central zone, and Rovnya in the northern zone. The increase in yield of Yarilo and Rovnya varieties compared to the control ranged from 0.13 to 0.16 t/ha, or from 4.2 to 5.2%. The smallest significant difference in yield for varieties was 5.4–15.8%. In the central zone of the region, the Yarilo variety significantly exceeds the standard by 0.69 t/ha, or 28.3%, in the north, the Grebeshok and Ukro varieties are significantly inferior to the standard by 0.16 and 0.33 t/ha, or 5.6 and 11.5%. The genetic series of the yield potential of varieties in the area of Karmen> Yarilo> Rovnya>Grebeshok > Ukro. A model of factors determining the adaptive potential of triticale in the Amur region is proposed.

1 Introduction

Currently, among the cultivated spring grain crops in the Amur region, wheat occupies the first place. Over the past 10 years, the variation in gross grain yields has reached 72.6%. The deviation in the sown areas of grain crops during this time was within 11.9%, and the yield, depending on the conditions of the year, differed by 2.3–2.6 times [1]. The variability in the size and quality of the harvest of spring grain crops here depends to a greater extent on environmental and anthropogenic factors and, to a lesser extent, on the biological characteristics of crops [2, 3]. In recent years, the number of animals and birds has

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increased in the region, and the demand for fodder grain of local production has increased [4].

If in Belarus and the western regions of Russia the wheat-rye hybrid triticale (×Triticosecale) confidently develops new sown areas, then its progress in the Far East is very modest, since the main crop in the structure of sown areas is soybean [5-7]. It is used for food and forage purposes, for the preparation of succulent and dry and combined feeds, as green fodder and a component of haylage, as bedding and organic fertilizer [8]. Perhaps in the future, triticale may become the main fodder crop for animal husbandry [9].

Variety is the main factor in increasing the yield of the crop. However, in order to obtain high and stable yields, an appropriate agricultural technique must be developed for it [10]. Modern models of farming consider the factors acting on cultivated plants - space, climatic, soil, biological, anthropogenic in mutual connection and dependence [11-12]. Yield is a product of the activity of genetic features inherent in the plant, climate, soil and people. The potential of a crop and variety reveals its cultivation technology. In the conditions of areal distribution, more often consider the adaptive potential of the crop or the limit of its resistance to adverse biotic and abiotic factors. Such as insect pests, diseases, weeds, salinity, increased acidity and alkalinity of soil, lack or excess of moisture, low or high temperatures, duration and intensity of light and others [13]. The really possible yield of triticale in a favorable combination of all agroclimatic resources reaches 13.2 t/ha. The variation in its yield due to climatic factors is 54.7%, or 2 times higher than in rye [14].

The purpose of this study was to establish the average and maximum values of the main production and economic indicators of triticale varieties in different soil and climatic zones of the Amur region.

2 Materials and methods

The study of spring triticale in 2012-2016 was conducted in the south of the Amur region at the State Variety Testing Station (SVTS), Kozmodemyanovka village, in the central part at the Svobodnensky State Variety Testing Station , Nizhnie Buzuli village, and in the north - at the Mazanovsky State Variety Testing Station, Beloyarovo village. The soil in the southern zone is meadow-chernozem-like [15]. It has humus of 3 - 6%, mobile phosphorus P_2O_5 - 84 mg/kg of soil, exchangeable potassium - 235 mg/kg of soil. In the central part - brown forest: humus 3 - 5%, phosphorus - 89 mg/kg, potassium - 61 mg/kg. Meadow soil in the north: humus 1 - 3%, phosphorus - 64 mg/kg, potassium - 81 mg/kg [16]. In 2012, meteorological conditions were characterized by sharp temperature variations and uneven distribution of precipitation. The first half of the season 2013 was warm and humid, the second relatively cooler with excessive precipitation. The vegetation of plants in 2014 took place against the background of higher temperatures and uneven distribution, but sufficient precipitation. In 2015, a lower temperature background and a deficit of moisture in summer were noted. 2016 was characterized by early spring and unstable temperature conditions with frequent rains in summer.

The following varieties were studied: 1. Karmen - standard (st); 2. Grebeshok ; 3. Rovnya; 4. Ukro; 5. Yarilo. All varieties of domestic breeders. The zoned variety Karmen was taken for control. We used the same seeds, approaches in planning, placement and conducting of the experiment. Total length of plot was 28.8 m, recording length was 24.8 m. Planting area of the plot was 47.5 m2, recording area was 40.9 m2. Repeatability was fourfold, plot placement was randomized. Experimental results were processed by analysis of variance using Microsoft Excel computer program [17].

The precursor was pure fallow. Soil treatment included early spring harrowing in early to mid-April, two to three days before sowing cultivation with harrowing. Sowing dates in the southern zone were the second ten-day period of April, in the central zone - the third

ten-day period of April, and in the northern zone - the first ten-day period of May. For sowing we used a seeder CN-16P (11-row, width - 1.65 m). Seeding rate of each variety was 6 million germinated grains per 1 ha. Seeding method - continuous row. Width between the rows - 15 cm. Sowing was rolled. Care consisted in harrowing before sprouting and after sprouting.

3 Results

The longest growth period in all zones of the region had the variety of spring triticale Yarilo, but it was 4 - 6 cm behind the regionalized variety Karmen in terms of stem height. In the central part and in the south, the Grebeshok variety stood out in terms of early maturity. It, along with the variety Ukro, in the central part of the region was the lowest. The greatest deviation from the average values for the duration of the growing season during the experiment 8.2 - 6.4 days or 7.5% - 7.6% was in varieties Rovnya and Yarilo in the south. Rovnya variety had the least deviation of 2.4 days or 3.2% in the central part of the region. In terms of height in the south, variety Grebeshok was the same as the standard, and in the north below control by 2 cm. In the northern zone the most early maturing and low-growing variety was Ukro. On average, during the variety trials, triticale varieties grown in the south exceeded the varieties cultivated in the central zone by 9 days or 12% in terms of growth duration. Similarly, in the north, they grew 2.2 days or 3% longer than in the central part of the region. A similar pattern was noted in terms of stem height. In the south, plants were 23.8 cm or 31.4% higher and in the north, 7.2 cm or 9.5% higher than in the central zone (Table 1).

Table 1. Growth of spring triticale varieties in the Amur region (2012-2016).

Variety	Vegetation period, days			Stem height, cm		
	south	center	north	south	center	north
Karmen, st	84.4±4.4	74.8±3.8	77.8±3.2	104	80	87
Grebeshok	81.4±3.6	73.8±2.8	77.2±4.2	104	74	85
Rovnya	83.2±6.2	74.4±2.4	74.2±5.2	95	74	84
Ukro	84.2±5.2	74.0±4.0	74.0±6.0	97	75	77
Yarilo	84.4±6.4	75.0±4.0	79.8±4.8	98	76	82
Average	83.4±2.0	74.4±0.6	76.6±3.2	99.6	75.8	83.0

The longer the growing season of triticale varieties, the higher their stems grow. The stem height potential of triticale in the south of the region is greater than in the northern and central regions. The varieties of spring triticale Karmen, Scallop and Yarilo have high growth potential in the conditions of the region.

The productivity potential of cultivated plants for various reasons decreases both during cultivation and harvesting. Grain threshing is an important complex indicator for crops harvested by combines. It depends on many factors. Let us consider the effect of genetic characteristics of varieties in different conditions of the region on this indicator. The highest score of threshing capacity - 5, got the variety Karmen in the south of the region. Other varieties tested here were inferior to it by one point. In the central part of the region, the variety Karmen also had a high threshing score. The varieties Rovnya were inferior to it by 0.5 points, and Grebeshok , Ukro and Yarilo by one point. In the northern zone, the variety Karmen was also in first place in terms of threshing capacity of grain. Here, similarly to the central areas, variety Rovnya was inferior by 0.5 points, Grebeshok and Yarilo by one point, and variety Ukro by two points. Evaluating the grain harvest in the average for the region, the varieties can be placed in the following order: first place -

variety Karmen, second - Rovnya, third - Grebeshok and Yarilo, and the fourth - variety Ukro. Different growing conditions in the zones of the region also affected the threshing of grain. The best conditions for threshing of grain of all varieties are in the south of the region. On average by varieties the ear threshing is 0.4 points or 9.5% worse in the central zone and 1.1 points or 26.2% worse in the northern zone, compared with the southern zone (Table 2).

Table 2. Grain varieties of spring triticale in the Amur region (2012-2016).

Variety	Threshing, point			Weight of 1000 grains, g		
	south	center	north	south	center	north
Karmen, st	5	4.5	4.0	42.42±9.72	31.00±8.80	36.56±8.46
Grebeshok	4	3.5	3.0	37.18±6.48	29.96±6.36	36.16±9.06
Rovnya	4	4.0	3.5	41.76±8.86	33.24±7.04	37.78±10.9
Ukro	4	3.5	2.0	40.48±7.48	31.12±8.52	34.66±9.96
Yarilo	4	3.5	3.0	42.18±6.08	36.76±16.4	35.88±9.78
Average	4.2	3.8	3.1	40.80±3.62	32.42±4.34	36.21±1.55

The index of the weight of 1000 grains, is closely related to the maturity, size, nature and other qualities of the grain. This indicator of grain quality is higher in the south of the region in varieties Karmen and Yarilo, in the center it is higher in - Yarilo and in the north of the region - in varieties Rovnya, Karmen and Grebeshok. On average, during the time of research in the region, triticale varieties in order of decreasing weight of 1000 grains can be arranged in the following sequence: first place goes to the variety Yarilo - 38.27 g, second - Rovnya 0.68 g less or 1.8%, third - Karmen 1.66 g less or 4.3%, fourth - Grebeshok 3.84 g or 10% and fifth - Ukro - 3.85 g or 10.1% less. Triticale grain weight ranking by zone of the region - first place - southern, second - northern by 4.59 g or 11.3% less and third - central by 9.38 g or 20.5% less. The high potential for grain is formed in the southern zone of the region both by threshing and by the weight of 1000 grains. Here it is possible to organize elite seed production of spring triticale varieties.

On average for the five years of the experiment, the highest yield in the southern zone of the region was obtained for triticale variety Karmen, in the central zone - Yarilo, in the northern zone - Rovnya, and on average for the region - Rovnya variety. The yield increase of varieties Yarilo and Rovnya, relative to variety Karmen was from 0.13 to 0.16 t/ha or from 4.2 to 5.2% (Table 3).

Table 3. Yield of spring triticale varieties in the Amur region, t/ha (2012 - 2016).

Variety	South	Center	North	Average	Addition	
					т/га	%
Karmen, st	4.13	2.21	2.95	3.09	-	-
Grebeshok	3.59	2.30	2.79	2.89	-0.20	-6.5
Rovnya	4.12	2.56	3.07	3.25	+0.16	+5.2
Ukro	3.71	2.28	2.62	2.87	-0.22	-7.1
Yarilo	3.94	2.85	2.89	3.22	+0.13	+4.2
Average	3.89	2.44	2.86	3.07	-0.02	-0.6
LSD_{05},variety	0.22	0.37	0.15			
LSD_{05}, year	0.21	0.35	0.14			

In order to identify the effects of the studied varieties of spring triticale we established the reliability of the experiment. Yield data of varieties were processed by the method of

analysis of randomized repetitions (blocks) with increased repetition of variants. The correction factor C, sums of squares of deviations (C_y, C_p, C_v, C_z), degrees of freedom, mean square were calculated for each zone of the region. The actual value of Fisher's criterion $F_ф$ for the years of experiment on Tambov State Variety Testing Station 12.9 times, on Svobodnensky State Variety Testing Station 4.6 times, and on Mazanovsky State Variety Testing Station 31.8 times more than theoretical F_{05} or tabulated - 2.00. There are significant differences between the variants at the 5% level of significance. $F_ф > F_{05}$, the null hypothesis $H_0 : d = 0$ when compared with T'yuki 's D -criterion is rejected. The error of experience s_x respectively the zones of the region was 0.0754 t, 0.1235 and 0.0514 t. When comparing the varieties over the study period (20-fold repetition), the error of the difference of the averages according to the zones of the experiment was 0.1131 t/ha, 0.1852, and 0.0772 t/ha, and in 5-fold (year) sS_d corresponded to 0.1067 t/ha, 0.1746 and 0.0728 t/ha. The least significant difference (LSD_{05}) of 5% significance level in relative values respectively for the varieties for the zones was 5.8%, 15.8% and 5.4%, for the study year 5.5%, 14.3% and 5.1%. LSD_{05} in absolute values is shown in Table 3. This means that in the south of the region varieties Grebeshok and Ukro significantly inferior to the standard by 0.59 and 0.42 t/ha or 15.2 and 10.8%, and the yield of varieties Rovnya and Yarilo not significantly different from that of the variety Karmen. In the central zone of the region, the variety Yarilo by yield significantly exceeds the standard by 0.69 t/ha or 28.3%, the yield of other varieties of spring triticale does not differ significantly from the control. In the north of the region, the varieties Grebeshok and Ukro are significantly inferior to the standard by 0.16 and 0.33 t/ha or 5.6 and 11.5%, and the yield of other varieties is at the control level.

From the diagram in Figure 1 we can see that on average for 5 years, the highest plant height and grain ear threshing were more in variety Karmen. According to the duration of vegetation period and 1000 grains weight the variety Yarilo stood out, and according to the yield the variety Rovnya.

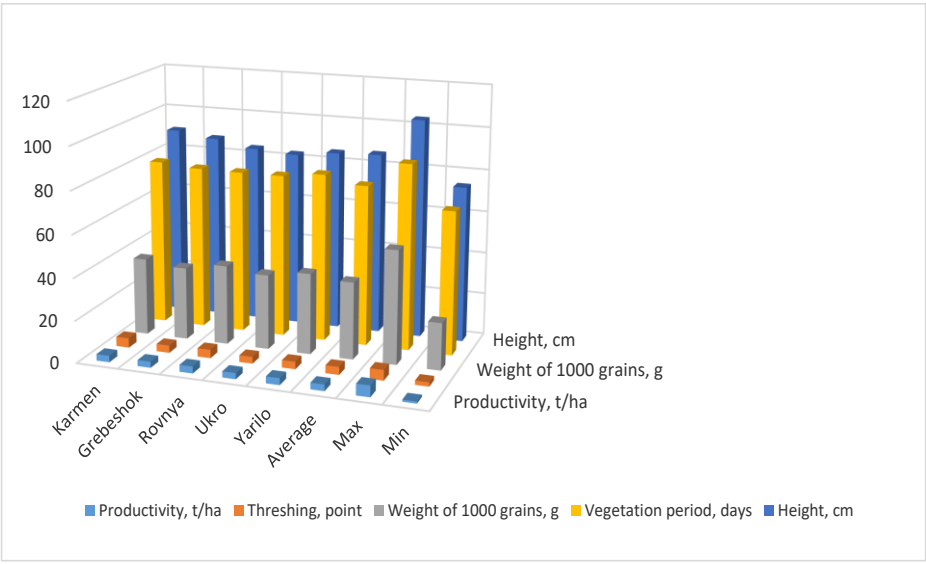

Fig. 1. Average and marginal productivity of triticale varieties in the Amur Region.

The shortest growing season was observed in the varieties Rovnya 69 days and Ukro 68 days in 2012 at Mazanovsky State Variety Testing Station. The longest it was in 2014 for varieties Karmen, Ukro and Yarilo 88 days at Tambov State Variety Testing Station. The lowest weight of 1,000 grains was 22.2 g and 22.9 g for Karmen and Ukro at

Svobodnenskoe State Variety Testing Station in 2016, and the highest in 2016 for Karmen - 53.6 g at Tambov State Variety Testing Station , it was slightly inferior to Yarilo - 53.2 g in 2015 at Svobodnenskoe State Variety Testing Station. The lowest yield of 0.95 t/ha was obtained in 2013 at the Svobodnenskoe State Variety Testing Station , as well as the highest in 2016 in the variety Karmen - 5.36 t/ha at the Tambov State Variety Testing Station , it was slightly inferior to the variety Yarilo - 5.32 t/ha in 2015 at the Svobodnenskoe State Variety Testing Station. The genetic potential of triticale varieties in order of yield increase can be represented by the following row Karmen> Yarilo> Rovnya> Grebeshok> Ukro.

4 Discussion

Literally, potential (from Latin potentia - strength, power) is a physical quantity, but it is used in various branches of science, society, and even in evaluating of a person's personality [18]. It implies an aggregate, a stock of capabilities, means, sometimes latent. In biology, for example, membrane potential, action potential, resting potential, in agronomy - bioclimatic, photosynthetic, adaptive potential [19]. Adaptive potential is understood as the genetically inherent ability of plants to adapt to adverse environmental conditions, survive in them, and produce offspring [20-22]. All agricultural crops according to the threshold of resistance to adverse agro-ecological factors and regimes are divided into: the first group - with a wide range of adaptability and insignificant restrictions on placement in the rotation - rye, oats, forage grasses. The second - with a medium range of adaptability, which are divided into: resistant to acidity and demanding nutrient elements of soil - flax; negatively responsive to high moisture, acidity and alkalinity of soil - barley, millet; demanding to relief, granulometric composition, arable layer, moisture, acidity and alkalinity of soil - winter and spring wheat, sunflower; the same requirements, but additionally to the nutrient and water-salt soil regime - potatoes, corn, beets and others. The third group - with a narrow range of adaptability and limited placement on land use demanding to all factors of life and soil fertility - vegetable crops, melons [23]. No doubt, the biological features of spring triticale have a wide threshold of resistance to adverse conditions and allow it to be included in the first group of adaptability.

It was found that in the northern areas triticale plants grow and develop faster, forming vegetative and food mass less than in the conditions of the southern zone of the region. This is due to the fact that in the north the daylight hours are longer and the weather is cooler, and by biological characteristics triticale is a cold-resistant plant with a long day. This pattern does not contradict the natural laws of nature and the theory of photosynthesis [24]. The model of factors influencing the degree of disclosure of the adaptive potential of cultivated plants can be presented in the following scheme (Figure 2).

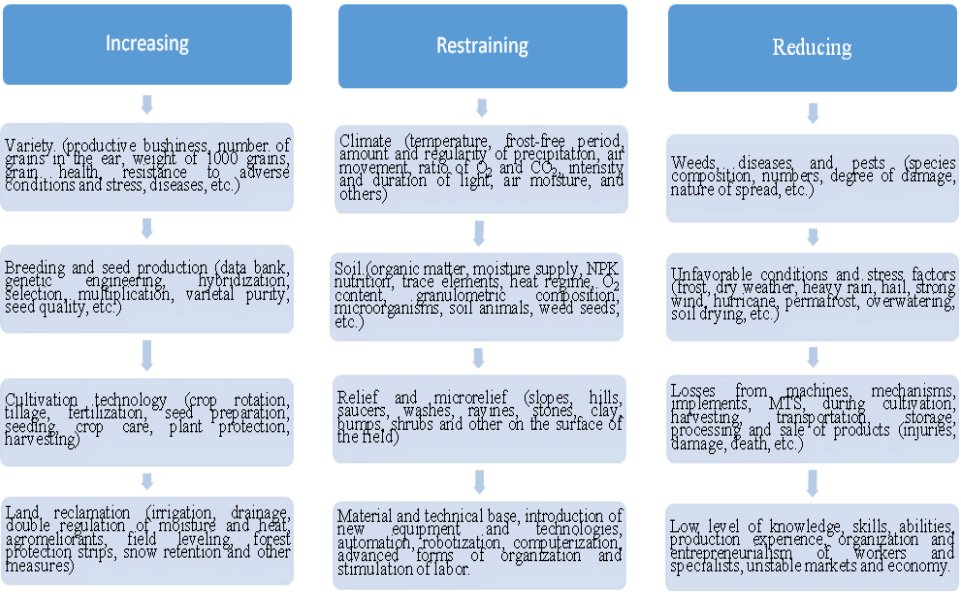

Fig. 2. Factors determining the adaptive potential of triticale in the Amur region.

We propose to divide the factors into three groups: 1st one increasing the adaptive potential - variety, breeding, farming techniques, reclamation; 2nd one restraining it - abiotic, edaphic, topographic, introduction of advanced achievements; 3rd one reducing genetically inherent advantages - biotic, stress, losses due to imperfection of machinery and due to production and economic activities of people. All these factors are interrelated, interdependent, act in a complex and simultaneously, and the potential reaches its maximum value at the optimal combination of agro-ecological conditions for the cultivated crop, which agrees with the basic laws of agriculture [25, 26].

5 Conclusions

Thus, the most early maturing variety in the central zone and in the south of the region was the Grebeshok, and in the north - Ukro, and late maturing in all zones is a variety of spring triticale Yarilo. Late maturing varieties in all zones of the region form a high stem. Location of triticale varieties by grain threshing Karmen> Rovnya> Grebeshok and Yarilo> Ukro. The highest grain potential by threshing and by weight of 1000 grains in the southern zone. The highest weight of 1000 grains - 53.6 g and yield 5.36 t / ha forms the variety Karmen in the south of the region. The highest yield in the central zone gives Yarilo, in the northern zone - Rovnya. Yarilo and Rovnya added to the yield of varieties compared with Karmen ranged from 0.13 to 0.16 t / ha or 4.2 to 5.2%. The smallest significant difference in yield by zones for varieties was 5.4 - 15.8%. In the central region varieties Yarilo yield significantly exceeds the standard by 0.69 t / ha or 28.3%, in the north varieties Grebeshok and Ukro significantly inferior to the standard of 0.16 and 0.33 t / ha or 5.6 and 11.5%. Genetic series of yield potential of varieties in the region Karmen> Yarilo> Rovnya> Grebeshok> Ukro.

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