Assessment of winter triticale genotypes in the selection of grain-feed varieties for the foothill zone of the Central Caucasus

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Abstract. The article presents the results of evaluation of winter triticale initial material for economically valuable traits for grain and forage areas breeding varieties. The object of research were winter triticale cultivars of different ecological and geographical origin: Hortenso, Moderato (Poland), Prader (Switzerland), TGI 22/1, GR-16/2 (Russia), 88 T 142 KS (USA). Grade Valentino 90The was taken as standard. Statistical methods for evaluating grades plasticity and stability as well as plant productivity index (PPI) were used to assess the genotypes adaptability. It is specified that yields above 1 t/ha on average over the three years showed the following cultivars: Moderato (1,05 t/ha), GR 16/2 (1,14 t/ha) and Hortenso (1,19 t/ha). The following cultivars: Valentino 90 (13,2), Hortenso (12,7), GR 16/2 (13,5), Moderato (11,6) were highly productive according to PPI. In terms of ecological plasticity varieties were divided into groups: the value of bi close to one – varieties well adapted to the conditions of the region (Prader, Hortenso, GR 16/2), extensive varieties – bi less than unity (KS 88 T 142), intensive varieties – bi is greater than unity (Valentino 90, TGI 22/1, Moderato). In terms of homeostasis and breeding values the cultivars were distributed in the following order: Hortenso, GR-16/2, Valentino 90, Prader, TGI 22/1, Moderato, KS 88 T 142. Additional data obtained by the provocative sloping sites to determine the potential productivity and aftergrowth capacity. The best regeneration ability showed the following cultivars: Hortenso, GR 16/2, Moderato, Prader.

1. Introduction
The main directions of winter triticale use are the mixed-feed industries, baking, brewing, alcohol, and confectionery production [1, 2, 3]. Winter triticale feeding orientation is caused by high productivity of green mass to the total biomass of the plant and its quality (does not coarse until the end of milky stage), in contrast to the winter rye [4, 5].

Varieties of winter triticale grain and forage areas are characterized by high productivity of grain, yield of green mass and aftergrowth capacity [6, 7]. The feature of winter triticale is increased aftergrowth capacity after cutting, therefore, under favourable growing conditions it is possible to obtain several harvests of green mass, and in the aftermath of the first hay cutting to get the grain yield [8, 9]. To breed winter triticale varieties with high productivity of green mass, grain and aftergrowth capacity is a complex and time-consuming process as the main economic characters are complicated, determined...
by the aggregate of more simple properties and capable of change under the influence of different cultivation conditions [10, 11].

In this regard, in the process of breeding varieties evaluation methods of selection material on a range of economically important traits, including productivity, resistance to adverse climatic conditions, resistance to diseases and pests, product quality, etc are important [12].

For breeding of winter triticale grain and forage areas, we used the field and provocative assessment methods. A provocative assessment of the genotypes of winter triticale were used to determine the varietal characteristics of regrowing after removal of the main shoots. The advantage of provocative evaluation method is the regulation of the influence factor on the plant.

2. Materials and methods

The studies were conducted in 2017-2019 in the laboratory of grain crops selection and seed production NCRIMPA VSC RAS.

The research material was 7 winter triticale varieties of various ecological and geographical origin: Hortenso, Moderato (Poland), Prader (Switzerland), TGI 22/1, GR-16/2 (Russia), KS 88 T 142 (USA). The standard in the experiments was Valentin 90 variety. The variety belongs to the grain feed group, suitable for use on grain fodder and in the green conveyor, preparing early silage, haylage, pellets, briquettes. Accounting for productivity and phenological observations was carried out according to the methodology of the State crop variety test [13]. For statistical processing of the experiments results the methodology of B.A. Dospekhov was used [14]. Ecological plasticity was calculated by the linear regression coefficient (bi), by the method of S.A. Eberhart, W.A. Russell presented by W.Z. Pakudina and L.M. Lopatina. The resistance of varieties to stress factors (Ymin - Ymax) and the genetic flexibility of varieties ((Ymax + Ymin) / 2) were determined according to A.A. Rossielle, J. Hemblin method presented by A.A. Goncharenko. Homeostasis (Hom) and selection value (Sc) were calculated according to the V.V. Khangildina and N.A. Litvinenko method. In assessing the genotype – environment interaction, the plant productivity index (PPI) was used [15, 16, 17]. The variability of winter triticale varieties was evaluated in the experiment with mowing shoots in the stalk phase at a height of 5 cm, at reference sites (0.5 × 0.5 m²) in triplicate.

3. Results and discussion

An important component of the varieties characteristics is their adaptability to the cultivation conditions of the region. To describe this parameter, statistical methods are used to calculate productivity indicators such as homeostaticity and environmental plasticity. Homeostatic, derived from the word homeostasis, indicates genotypes that are capable of preserving the productivity potential as much as possible under changing cultivation conditions, i.e. to be stable. This property is described by indicators of homeostaticity (Hom) and selection value (Sc). The higher these indicators are, the higher the homeostaticity of the variety is. Ecological plasticity shows the responsiveness of a variety to changes in cultivation conditions. The indicator is the regression coefficient bi. It can be more, less, or equal to one. The greater the value is, the more responsive the variety is, while improving the cultivation conditions, and increases the yield.

The studied winter triticale varieties differed in productivity. Productivity above 1 t / ha for an average of three years was shown by the varieties: Moderato (1.05 t / ha), GR 16/2 (1.14 t / ha) and Hortenso (1.19 t / ha). The productivity of these varieties was at the standard level and there were no sharp fluctuations in productivity over the years (table 1).

Table 1. Average yield and adaptability parameters of winter triticale varieties.

| Variety  | Yield, t/ha | Average, t/ha | (Ymax + Ymin)/2 | PPI, average | bi  | Ymin-Ymax | Sc  | Hom  |
|---------|-------------|---------------|-----------------|--------------|-----|------------|-----|------|
| Valentin 90 | 1.05 | 0.97 | 1.0 | 1.01 | 13.2 | 2.6 | -0.08 | 0.87 | 3.6 |
| Moderato | 1.04 | 1.0 | 1.1 | 1.02 | 11.6 | 1.6 | -0.1 | 0.86 | 2.1 |
Variability of variety samples productivity \((Y_{\text{max}} + Y_{\text{min}})/2\) shows the average variety yield in contrasting conditions, characterizes genetic flexibility. At the level of the Valentin 90 standard, there were the following variety samples: Moderato, GR 16/2, Hortenso and TGI 22/1 with indicators of 1.02, 1.15, 1.2 and 0.97, respectively, i.e. these varieties are characterized by a high degree of correspondence of genotypes to environmental factors (table 1). The following samples had good stress resistance indicators: Hortenso (-0.03), TGI 22/1 (-0.05), Prader (-0.09), Valentin 90 (-0.08).

According to the values of the PPI index, the highly productive varieties are: Valentin 90 (13.2), Hortenso (12.7), GR 16/2 (13.5), Moderato (11.6).

In terms of ecological plasticity, the variety samples were divided into groups: the bi value is close to one — varieties well adapted to the conditions of the region (Prader, Hortenso, GR 16/2), extensive varieties — bi less than one (KS 88 T 142), intensive varieties — bi more units (Valentin 90, TGI 22/1, Moderato).

The slope of the regression lines gives visual information about the behaviour of varieties relative to each other and in comparison with the average response of varieties to changing growing conditions (figure 1).

| Variety     | 1.20 | 1.12 | 1.1 | 1.14 | 1.15 | 13.5 | 1.3 | -0.1 | 0.87 | 3.7 |
|-------------|------|------|-----|------|------|------|-----|------|------|-----|
| GR 16/2     | 1.20 |       |     |       |       |      |     |      |      |     |
| TGI 22/1    | 0.95 | 0.96 | 1.0 | 0.97 | 0.97 | 7.3  | 2.0 | -0.05| 0.88 | 2.4 |
| Prader      | 0.75 | 0.8  | 0.84| 0.8  | 0.8  | 4.3  | 0.8 | -0.09| 0.84 | 2.5 |
| KS 88 T 142 | 0.45 | 0.51 | 0.62| 0.52 | 0.53 | 3.1  | 0.6 | -0.17| 0.68 | 0.8 |
| Hortenso    | 1.20 | 1.18 | 1.21| 1.19 | 1.2  | 12.7 | 1.1 | -0.03| 0.96 | 4.4 |
| Average, Xj |      |      |     |      |      |      |     |      | 0.95 |     |

**Figure 1.** The regression line based on yield of \((X_i)\) for winter triticale varieties index of the medium \((X_j)\): 1 – Valentin 90; 2 – Moderato; 3 – GR 16/2; 4 – TGI 22/1; 5 – Prader; 6 – KS 88 T 142; 7 – Hortenso.
The breeding value is represented by those varieties whose regression lines rise high on the right side of the graph (favourable conditions), which characterizes their high responsiveness to improved conditions.

According to the indicators of homeostaticity and breeding value, the variety samples were distributed in the following order, with decreasing values: Hortenso, GR-16/2, Valentin 90, Prader, TGI 22/1, Moderato, KS 88 T 142.

The results of the experiment with mowing the stems in the stalk phase are shown in table 2. The cutting height is selected with the consideration of the complete removal of the rudimentary ears and growth cones, to level the phenomenon of apical dominance.

In cereals, as in other plants, the apical meristem of the growth cone inhibits the development of lateral buds by its hormonal influence (auxin). With the death of the main shoot, shoot formation is enhanced due to the influence of other phytohormones (cytokinin) synthesized in the root. The action of cytokinin is multifunctional. They affect cell division, enhance the growth of lateral shoots, increase the plant's resistance to a variety of adverse factors, such as increased or decreased temperatures, dehydration, fungal and viral infections, mechanical stress, etc.

The results obtained from the experiment indicate varietal differences in the ability to restore the stalk after mowing or other damage. For the standard variety Valentin 90, the regenerative capacity was 33.8%. The regenerative ability of the variety TGI 22/1 (31.0%) was at the same level. Other cultivars showed the best results: Hortenso (60.4%), GR 16/2 (55.7%), Prader (47.8%), Moderato (47.4%). Variety specimen KS 88 T 142 (19.1%) showed a low level of creep. The bevelled plots method provides additional information on the variety specimens potential productivity.

**Table 2.** The structure of the productivity of winter triticale cultivars try on courage.

| Variation | Plant height, cm | The number of productive stems, pcs. | Ear length, cm | Number of grains per ear, pcs. | Grain weight per ear, g | Productivity, kg/m² | Regrowth, % |
|-----------|------------------|-------------------------------------|----------------|-------------------------------|------------------------|---------------------|-------------|
| **Valentin 90** |                  |                                     |                |                               |                        |                     |             |
| Control   | 100              | 339                                 | 10.0           | 43.4                          | 3.0                    | 0.365               | 33.8        |
| Mowing    | 84               | 215                                 | 7.5            | 36.8                          | 1.7                    | 0.185               | 7.5         |
| **Moderato** |                |                                      |                |                               |                        |                     |             |
| Control   | 118              | 359                                 | 11.0           | 49.2                          | 2.8                    | 0.479               | 47.4        |
| Mowing    | 100              | 266                                 | 8.0            | 38.1                          | 1.8                    | 0.479               | 47.4        |
| **GR 16/2** |               |                                       |                |                               |                        |                     |             |
| Control   | 110              | 355                                 | 14.1           | 63.3                          | 3.7                    | 0.612               | 55.7        |
| Mowing    | 100              | 220                                 | 10.0           | 50.1                          | 2.8                    | 0.479               | 47.4        |
| **TGI 22/1** |                |                                      |                |                               |                        |                     |             |
| Control   | 115              | 308                                 | 10.7           | 64.7                          | 3.0                    | 0.924               | 31.0        |
| Mowing    | 90               | 178                                 | 10.0           | 42.3                          | 1.6                    | 0.285               | 31.0        |
| **Prader** |                 |                                       |                |                               |                        |                     |             |
| Control   | 97               | 324                                 | 9.7            | 41.5                          | 2.1                    | 0.605               | 47.8        |
| Mowing    | 80               | 217                                 | 6.2            | 32.8                          | 1.5                    | 0.325               | 47.8        |
| **KS 88 T 142** |            |                                        |                |                               |                        |                     |             |
| Control   | 78               | 291                                 | 10.0           | 37                            | 1.7                    | 0.505               | 19.1        |
| Mowing    | 63               | 107                                 | 7.5            | 21                            | 0.9                    | 0.096               | 19.1        |
| **Hortenso** |                |                                      |                |                               |                        |                     |             |
| Control   | 110              | 320                                 | 11.6           | 70.7                          | 4.1                    | 1.312               | 60.4        |
| Mowing    | 95               | 264                                 | 9.5            | 55.8                          | 3.0                    | 0.792               | 60.4        |
4. Conclusion

According to the results of the research, we can distinguish winter triticale varieties with high productivity at and above the standard: Hortenso, GR 16/2, Moderato. The same variety samples are distinguished by high homeostaticity and breeding value. In terms of ecological plasticity, the following variety specimens are most suitable for cultivation conditions and responsive to their improvement: Moderato, GR 16/2, TGI 22/1, Hortenso. The variety samples: TGI 22/1, Prader, KS 88 T 142 showed lower productivity than that of the standard variety. Additional characteristics for determining the potential productivity and retention of the studied variety samples were obtained by the method of provocative bevelled plots. The best regenerative ability was shown by the variety samples: Hortenso, GR 16/2, Moderato, Prader. In general, for the winter triticale varieties selection of fodder and grain direction, you can use varieties: Hortenso, GR 16/2, Moderato, Prader.

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