Adaptability of new varieties of seed peas in the Krasnoyarsk forest-steppe

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Abstract. In the process of breeding work with the Pisum sativum culture, its manufacturability increases due to the introduction of new economically valuable features, as a result of the influence of abiotic factors on pea varieties is transformed. The work is relevant in timely identification of changes in influences and analysis of these transformations on the reconstructed genotype are important in breeding evolution. The material for the study was 12 samples of five varieties of Pisum sativum. The adaptability and stability indices of the samples – Indicator of the stability level of the variety, stability index, stress tolerance, breeding value, and the dependence of the adaptive properties of the culture on the complexity of its genotype were determined. The stress tolerance of the varieties was chaotic; its relationship with the evolution of the genotype is very weak. A strong positive relationship was revealed between the complication of the genotype and the coefficient of variation; a strong negative relationship was revealed between the resistance and stability index of the varieties. Strong negative dependencies were revealed between the evolution of culture and the stability index, as well as breeding value.

1. Introduction
Peas (Pisum sativum L.) is the most common leguminous crop [1], [2]. According to the expert-analogous center of agribusiness, the sown area in Russia from 2001 to 2018 increased by 112.5% (by 759.7 thousand hectares).

With the development of crop selection aimed at increasing its productivity and manufacturability, varieties are created that have a mustachioed leaf type, funicular seeds, short stems that are more resistant to lodging, and a determinant type of growth and development [3], [4]. In the process of breeding, plant genotypes undergo changes. From the point of view of genetics, it is known that the manifestation of signs of “mustache” and funicularity is controlled by the AF and DEF genes in the first and fourth chromosomes [3].

Harvest index of culture is approaching the biologically possible limit. But at the same time, the protein content of seeds decreases and resistance to biotic and abiotic factors is worsens [5], [6].

Makashova Rauza Khadievna (1973) [7], systematizing data on peas, identified 27 groups of varieties of Pisum sativum L., indicating that some of the varieties published in the press remained unclear, due to an insufficiently or unclear description.
The determination of varieties also causes difficulties due to the appearance of new morphotypes, for example, chameleons, determinants, dissected leaves, and others. Therefore Serdyuk V.P. and Stankevich A.K. [3] were identified new intraspecific taxa of planting peas, which need studies on adaptability, along with the varieties described by Makashova.

The need for such studies is determined by the dependence of the formation of crop structure elements by varieties on abiotic factors determined by the corresponding soil and climatic conditions [2], [8].

Researchers often analyze changes in the adaptive abilities of a culture with respect to a particular factor complicating the genotype and increasing overall manufacturability. For example, Filatova I.A. [9] in her experiments established that under the conditions of the Central Chernozem zone, cultivars with leafy morphotype have low ecological plasticity and greater stress resistance and homeostaticity compared to the moustached morphotype. Also, according to earlier studies, it was found that the stability level indicator for short-stalked pea lines is lower than that of medium-stalked ones [4], [10]. An analysis of changes in adaptive abilities in the context of the overall complexity of the culture genotype has not been previously conducted in the region. In this connection, the relevance of this work is not in doubt.

The aim of this work was to determine changes in the adaptive abilities of the Pisum sativum L. species due to the complexity of its genotype.

In this connection, the following tasks were set:

- Determine the indicators of adaptability and stability indicators of the samples - PUSS (indicator of the variety's stability level), stability index, stress resistance, breeding value, as well as the coefficient of variation for the studied varieties of peas.
- To reveal the dependence of the adaptive properties of a culture on the complexity of its genotype.

2. Materials and methods of research
The studies were conducted in forest-steppe zone of the Krasnoyarsk territory, in the fields of KrasRIA (Krasnoyarsk Research Institute of Agriculture). The soil of the experimental plot is ordinary heavy-loamy black earth. The content of nitrate nitrogen (N-NO3) in the arable layer is low (4 ... 6 mg/kg of soil). The content of mobile phosphorus (P2O5 - 19.7 mg/100 g) and potassium (K2O - 12.6 mg/100 g) (according to Chirikov) - medium and high, respectively. The humus content in arable humus in the arable layer is 7.8% (according to Tyurin). The acidity of the soil solution is close to neutral (pH = 6.8).

| Table 1. Meteorological conditions in the research years (2017-2019). |
|-----------------------------|--------------------------|--------------------------|------------------|
| Month                      | Deviation from the average annual value | Average 2017-2019 |
|                            | 2017 | 2018 | 2019 |       |
| May                        | 1.1  | -2.1 | 0    | -0.8  |
| June                       | 4.8  | 5.0  | 3.2  | 4.7   |
| July                       | -0.2 | -1.2 | 0    | 0.1   |
| August                     | 0.4  | 2.6  | 2.3  | 1.2   |
| Average for the period     | 1.5  | 1.1  | 1.3  | 1.3   |
| Precipitation, mm          |     |     |     |       |
The predecessor is pure steam. Soil cultivation was carried out according to zonal recommendations [11]. In the fall, dump plowing was carried out, and in the spring - harrowing and pre-sowing cultivation were carried out. Sowing was carried out with the SSFK-7 seeder at a rate of 1.3 million germinating seeds / ha in the first or second decade of May, depending on weather conditions.

Meteorological conditions during the years of research differed from the average annual. Meteorological conditions during the years of research differed from the average annual. 2017 was characterized as excessively wet (SCC = 1.5); 2018 is a very dry year (SCC = 0.6) due to lack of moisture in all summer months; In general, 2019 was a dry year (SCC 0.9), mainly due to insufficient rainfall in May and August (table 1).

The research was conducted in accordance with the methodology of the state variety testing of agricultural crops [12], in the nursery of competitive variety testing. The area of plots is 15 m2, the repeatability is four-fold, the method of placing plots is randomized.

For research, 12 varieties and breeding numbers of six varieties were taken. In determining the varieties of the material used was used as a taxonomy by Makashova R.Kh. [7], and the taxonomy by Serdyuk V.P. and Stankevich A.K. [3].

Var. Vulgare (according to Makashova) (ordinary variety) - a tall or medium-sized plant, the internode are long. Corolla unpigmented. Seeds are light-colored, medium in size (weight of 1000 seeds 150 - 250 g) - variety Radomir.

Var. Ecaducum (according to Makashova) (a variety of non-falling) stalk of medium length or long (81 cm or more). The internodes are long. The corolla is white. Seed rind fused with the cotyledon, seed without a scar. Selection samples Zh-60, Zh-43, Zh-58.

Var. Cirrosum (according to Makashova) - a variety with a whiskered leaf type and a medium-long stem; var. Cirrosum-ecdacum-a variety with a "mustachioed" leaf, non-falling seeds and a medium-long stem-Yakhont, Zh-55.

Var. Persistens (according to Stankevich) (the remaining variety) is a white corolla, a bean with a parchment layer, seeds are yellow-pink, smooth, spherical. The Cotyledon has grown to a scar and a placenta. The mass of 1000 seeds 230 - 260 g. – breeding lines D-39, D-94, G-259. The stem length of these samples ranges from 40 - 65 cm.

Var. Cirriferum - a variety with a "semi-dwarf" stem with limited growth, a mustachioed leaf type and non-falling seeds - selection lines G-171, G-178, D-40. These lines are also short-stemmed - with shortened internodes.

The level of stress tolerance was defined as $U_2 - U_1$, where $U_2$ is the minimum yield, $U_1$ is the maximum. The best stress tolerance of a variety is determined by the smaller difference in indicators $U_2$ and $U_1$, the smaller their difference, the more stress resistant the variety is, that is, it forms a good crop in different environmental conditions [13].

ISLV - the indicator of the level of stability of the variety was determined according to Nettevich [14], as the product of the average value of the yield indicator by the index of stability of the variety.

The stability index was calculated as the quotient between the average value and the coefficient of variation. Selection value was determined by Hangeldin [15].

3. Research results

The stability index is an important characteristic of a variety. Varieties with a large stability index are more stable and adapted to these environmental conditions [16]. Variety Radomir leaflet, with crumbling seeds - with a set of dominant alleles according to these characteristics, had the highest stability index (17.48). A lower stability index was found in breeding samples of cirriferum varieties (mustachioed leaf,
short stalk) - G-178 (4.77) and Persistens (mustached leaf, non-shedding seeds, short stalk) D-94 (4.07). Leaflet lines with seedless seeds were on average inferior in this indicator to the Radomir standard, varieties of vulgare by 7.04; mustached mid-stem lines with non-shedding seeds at 8.5; short stem whiskered lines at 12.58; short-stemmed mustached with non-shedding seeds at 11.64.

Yakhont (-13.90) and Radomir (-17.65) varieties had the best stress resistance – the ability to resist stress caused by adverse factors, as well as selection samples G-178 (-16.57), D-40 (-17.92), and D-94 (-16.22), the other selection samples had a level of stress resistance ranging from -18.45 - selection sample D-39 to -24.15 - sample Zh-58.

A higher indicator of the stability level of the variety (ISLV) was characteristic of the variety Radomir (16.22), Var. vulgare, the lowest level of variety stability was possessed by the selection sample G-171, Var. cirriferum (12.09).

The leaf variety Radomir had the lowest coefficient of variation (3.47 %), the largest variation in yield was determined in the short-stemmed mustachioed selection sample G-178 (13.18%) (table 2, figure 1).

| Variety         | Sample     | CV  | ISLV | Stress Resistance | Stability index | Selection value, % |
|-----------------|------------|-----|------|-------------------|-----------------|---------------------|
| Vulgare         | Radomir, St| 3.47| 16.22| -17.65            | 17.48           | 10.4                |
| Ecaducum        | W-60       | 3.80| 14.19| -19.72            | 14.48           | 9.04                |
|                 | W-43       | 10.95| 13.21| -23.32            | 8.15            | 8.36                |
|                 | W-58       | 5.67| 14.09| -24.15            | 8.70            | 8.81                |
| Cirrosum - ecaducum | Yakhont    | 4.70| 12.68| -13.90            | 10.93           | 7.91                |
|                 | W-55       | 7.12| 14.09| -20.85            | 7.03            | 8.73                |
| Cirriferum      | G-171      | 12.93| 12.09| -19.95            | 3.58            | 6.92                |
|                 | G-178      | 13.18| 12.8 | -16.57            | 4.77            | 7.46                |
|                 | D-40       | 8.98| 14.39| -17.92            | 6.35            | 8.61                |
| Persistens      | D-39       | 9.52| 13.16| -18.45            | 6.29            | 7.56                |
|                 | D-94       | 10.10| 13.67| -16.22            | 4.07            | 8.18                |
|                 | G-259      | 7.37| 13.18| -23.25            | 7.16            | 8.01                |

If all the studied varieties are placed taking into account the complexity of their genotype as a result of the introduction of genes that are responsible for new economic and valuable features: 1 – Var. vulgare; 2 – Var. ecaducum; 3 – Var. cirrosum-ecaducum; 4 – Var. cirriferum; 5 – Var. Persistens, it is possible to identify the relationship between the evolution of culture and indicators of its adaptability.
The stress tolerance of the varieties was chaotic, so the relationship between the stress tolerance index of the varieties and the evolution of the culture genotype was very weak ($r = 0.200 \pm 0.310$).

A strong positive relationship ($r = 0.807 \pm 0.341$) was revealed between the coefficient of variation and complexity of the genotype.

According to the results of our research for 2017 - 2019, between the index of resistance and stability of varieties and the evolution of culture in the conditions of the forest-steppe of Eastern Siberia, a strong negative relationship was revealed ($r = -0.800 \pm 0.354$).

Strong negative dependences ($r = -0.914 \pm 0.234$) and ($r = -0.883 \pm 0.271$) were found between the evolution of culture and the stability index, as well as breeding value. Var. vulgare had a higher stability index (17.48), the smallest - in Var. cirriferum (4.90) (figure 1).

4. Conclusions

Thus, on the basis of the conducted studies, it can be concluded that with the process of evolution and complication of the culture genotype, the adaptive abilities of the culture which expressed in terms of the stability and breeding value of the samples, stability index, breeding value is weakened, and the range of variation in yield increase.

For a more objective analysis of the conclusions it is necessary to conduct similar studies on large numbers of varieties and varieties of samples, more years, as well as in different soil and climatic conditions.

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