Ecological variability of the quality of oats varieties depending on vegetation conditions

I B Trifuntova*

Far Eastern Agricultural Research Institute, Vostochnoe 680521, Russia

*E-mail: borimel@bk.ru

Abstract. Studies were conducted on the environmental variability of the quality of oat varieties depending on the growing conditions in the Khabarovsk territory (Russia). In recent years, the demand for high-quality oat grain has increased. The conditions for cultivating grain crops in the same soil and climate zone are very diverse. The research was aimed at studying the influence of the environment during the growing season on the quality of oats. It was noted that the most affected indicators were grain firmness (coefficient of variation (CV) is 16.8%) and the content of lysine in the grain (CV is 18.8%). To an average extent, the conditions of the year affect the characteristics of the protein content in the grain (CV is 10.1%) and the nature of the grain (CV is 14.5%), which is determined by the ecological fitness of oat varieties when cultivated in the region. The low variability of the 1000 grain weight trait (CV is 9.4%) indicates a weak response of oat genotypes to changes in environmental conditions. Based on a set of quality indicators, the varieties of oats Marshal, Cardinal and Peredovik. The Marshall oats variety was characterized by a high and stable protein and lysine content. In the variety Peredovik, a high mass of 1000 grains and a full grain weight were noted. Over the years of research, the Cardinal oat variety had a low pitting and a large mass of 1000 grains. We recommend them for sustainable crops of high-quality grain for various food uses. These varieties of oats are recommended for cultivation in the Khabarovsk Territory.

1. Introduction

As agricultural production develops, breeding plays the most important role in increasing plant productivity [1,2]. The variety is not only a means of increasing productivity, but also a factor without which it is impossible to fully realise the potential of all the achievements of science and technology. In agricultural it is an indispensable biological the system [3]. The effectiveness of cultivar creation depends to a large extent on the genetic diversity of the source material studied. Poorly studied source material can reduce the resistance of the cultivated varieties to biotic and abiotic factors [4, 5].

The creation of new varieties of agricultural crops that are maximally adapted to the specific conditions of cultivation in each ecological zone is due to the wide variety of soil and climatic conditions in Russia. Many authors believe that to ensure a stable yield and formation of high-quality grains, varieties must have a wide range of responses to changing environmental factors [6–10]. Currently, oats is a promising agricultural crop in terms of new ways of processing raw materials [11], because it has a number of valuable properties [12] that meet the requirements of the functionality of food products, as well as allowing it to be used for feed and medical and preventive purposes [13].
Our research was aimed at studying the influence of weather conditions on the quality indicators of grain varieties of oats. We studied the reaction of oat varieties to fluctuations in meteorological environmental conditions during the growing season.

2. Materials and methods
The studies were conducted in 2015–2019, in a remote area of the Far Eastern Scientific Research Institute of Agriculture (FERIA) in the Khabarovsk Territory (Russia). The object of research was the hulled oats varieties of breeding FERIA: Express (standard variety), Tigrovy, Premier, Marshal, Cardinal and Peredovik. The predecessor in the experiment was black vapour. The soil of the site was bore-podzolic, with a loamy mechanical composition, an acidic reaction of the medium (pH salt <4.0–4.5), hydrolytic acidity of 8–10 mEq, the sum of exchange bases of 10–14 mEq per 100 g of soil, a very low content of mobile phosphates and a high content of exchange potassium. The content of humus did not exceed 3.5%. Sowing of oats was carried out in a randomised manner in a threefold repetition. The plot area was 12 m². The sowing rate was five million germinating grains per hectare.

Physico-biochemical indicators of grain quality were determined in the Institute’s agrochemical laboratory. A mass of 1000 grains was counted: two average samples of 500 grains, weighed on a laboratory balance accurate to the second decimal place. The arithmetic average of two results of a mass of 1000 grains was taken as the final version. The protein content in the grain was determined by the Kjeldahl method. This method consists in the mineralisation of organic matter with sulphuric acid in the presence of a catalyst with the formation of ammonium sulphate, the destruction of ammonium sulphate with alkali with the release of ammonia, and the distillation of ammonia with water vapour in a solution of sulphuric or boric acid, followed by titration. The quantitative lysine content in the grain was determined by the ninhydrin method using a photocolorimeter in a green filter at a wavelength of 540 mm. The natural weight of grain in Russia was taken as a mass of 1 litre, calculated in grams. The oat grain membrane is the ratio of the number of shells to the total amount of unbroken grain, expressed as a percentage.

Agroclimatic conditions of vegetation periods from 2015 to 2019 were characterised by variability in the provision of heat and moisture during the growth and development of oat plants. The conditions for 2017 were optimal for the formation of high-quality indicators. A small amount of precipitation and high average daily temperatures in August contributed to the formation of high-quality indicators of oat grain. In 2015 and 2016, the amount of precipitation for the period April–August exceeded the mean annual values by 30.0 and 40.8 mm, respectively. The agrometeorological conditions of vegetation in 2018 and 2019 were relatively favourable for the growth and development of oats. The sums of effective temperatures were: 2291 °C in 2015; 2298 °C in 2016; 2505 °C in 2017; 2302 °C in 2018; 2380 °C in 2019.

The data obtained were statistically processed by the method of variance and variance analysis. Coefficient of variation (CV) is a statistical measure of the dispersion (spread) of data around a certain average value.

3. Results and Discussion
Oat grain quality indicators are varietal hereditary traits, which makes it possible to further improve their selection. However, they are subject to strong variability under the influence of environmental conditions [16]. In our experiments, the quality of oat grains depended to a weak (CV < 10%) and medium (CV = 10–20%) degree on the year of cultivation (table 1). The weight of 1000 grains is the most important indicator of grain quality. The values of the mass of 1000 grains in our studies largely depended on the weather conditions of the region during the period of grain loading.

On average, the weight of the mass of 1000 grains varied slightly over the years (CV = 9.4 %). For the years of the experiment, the studied indicator was the lowest in 2016. The smallest varietal variability was noted for 2019, when the mass index of 1000 grains varied from 34.7 g in the oat variety Peredovik up to 40.5 g in the oat variety Marshal. The highest genotypic variability was noted...
for the year 2018: from 30.3 in the Tigrovy oat variety to 35.7 in the Cardinal oat variety. During the years of the research, 1000 grains of the standard variety Express had an average weight of 31.1 g.

Table 1. Variation of spring oat grain quality indicators depending on genotype and conditions of the year.

| Index                        | year   | min-max      | average   | CV, % | genotypic | on year |
|------------------------------|--------|--------------|-----------|-------|-----------|---------|
| Weight of 1000 grains, g     | 2015   | 30.8-34.8    | 31.1±0.75 | 6.1   | 5.7       |         |
|                              | 2016   | 27.6-32.8    | 29.4±0.58 | 6.1   | 5.7       |         |
|                              | 2017   | 31.6-39.8    | 37.7±0.62 | 5.9   | 9.4       |         |
|                              | 2018   | 30.4-35.7    | 33.4±0.59 | 9.4   |           |         |
|                              | 2019   | 34.7-40.5    | 36.4±0.43 | 5.0   |           |         |
| The protein content in the grain,% | 2015   | 9.8-12.6     | 10.7±0.78 | 2.2   |           |         |
|                              | 2016   | 10.9-13.1    | 11.7±0.42 | 3.4   |           |         |
|                              | 2017   | 11.9-12.8    | 11.2±0.34 | 2.8   | 10.1      |         |
|                              | 2018   | 10.9-12.7    | 11.3±0.26 | 2.7   |           |         |
|                              | 2019   | 11.7-13.4    | 11.9±0.37 | 2.6   |           |         |
| Grain lyzine, mg/100g        | 2015   | 177-278      | 211±0.43  | 18.6  |           |         |
|                              | 2016   | 227-366      | 280±0.27  | 16.5  |           |         |
|                              | 2017   | 213-338      | 260±0.45  | 18.2  | 18.8      |         |
|                              | 2018   | 214-312      | 258±0.27  | 14.7  |           |         |
|                              | 2019   | 170-290      | 260±0.41  | 20.3  |           |         |
| Grain weight, g/l            | 2015   | 440-550      | 480±2.92  | 15.4  |           |         |
|                              | 2016   | 427-530      | 462±4.84  | 12.4  |           |         |
|                              | 2017   | 550-680      | 590±2.71  | 19.7  | 14.5      |         |
|                              | 2018   | 500-610      | 554±2.81  | 11.3  |           |         |
|                              | 2019   | 510-650      | 584±3.94  | 14.1  |           |         |
| Grain film, %                | 2015   | 22.1-28.9    | 24.8±0.17 | 16.2  |           |         |
|                              | 2016   | 23.1-30.4    | 26.8±0.31 | 18.4  |           |         |
|                              | 2017   | 21.6-25.8    | 23.7±0.18 | 15.8  | 16.8      |         |
|                              | 2018   | 23.5-31.1    | 27.2±0.24 | 17.1  |           |         |
|                              | 2019   | 20.1-25.5    | 23.8±0.28 | 14.5  |           |         |

When assessing the quality of grain used for industrial processing, the protein content [17] should be taken into account. 88 g of digestible protein are contained in one feed unit of oat grain, and 101 g in the dry matter of the vegetative mass [18]. As a result of our research, it was found that on average over the years of vegetation, the protein content in the grain varied from 9.8% in the Tigrovy variety in 2015 to 13.1% in the Peredovik variety in 2016. The maximum protein content in grain (13.4%) was in the Marshall variety in 2019. The average variability of the protein content in the grain indicates a slight reaction of oat varieties to changes in vegetation conditions.

The balance of oat grain in terms of amino acid composition noticeably distinguishes this culture from wheat [19]; the content of the essential amino acid lysine is almost twice as high in oat as in wheat proteins [20]. In our experiment, the indicator of the lysine content in the grain was more susceptible to weather than other signs. The best year for the formation of a high content of lysine in oat grain was 2016. The maximum lysine content (366 mg/100g) this year was observed in the Marshall variety. Weather conditions were somewhat worse in other years of research. The trait with the greatest variability was the content of lysine in the grain in 2019. This year, the lysine content ranged from 170 mg/100 g in the Tigrovoy oat variety to 290 mg/100 g in the Cardinal oat variety. Over the years of research, the standard oat Express variety has an average lysine content of 210 mg/100 g of grain.
Grain nature is one of the important indicators characterising the performance and density of grain. This trait clearly differentiates varieties in response to stressful conditions during the period of grain filling. Among the stressful conditions that affect the nature of the grain include drought, dry winds, high daytime temperatures, excessive moisture, diseases and pests [21]. Depending on weather conditions, the average value of the indicator of grain nature ranged from 480 g/l in 2015 to 590 g/L in 2017. For varieties, the indicator ranged from 427 g/l for the Premier oats variety in 2016 to 680 g/L for the Peredovik variety in 2017. Strong variation of the trait was obtained in 2017 (CV = 19.7%). The average value of the variability of the characteristic grain nature was noted in 2018.

It is known that the value of the filminess of oat kernels varies widely and depends on the variety, plant growth conditions, the degree of maturity of the grain and its size. Outer films have low nutritional value, so it is advisable to reduce their mass fraction in oats [22]. In our studies, depending on the conditions of the year, the average value of the film index varied from 23.7% in 2017 to 27.2% in 2018. In varieties, this indicator ranged from 20.1% in the Cardinal variety in 2019 to 31.1% in the Tigravy variety in 2018. The maximum variation of the trait was obtained in 2016 (CV = 18.4%). This indicator was more stable under the conditions of 2019 (CV = 14.5%).

4. Conclusion
The most stable sign of oat grain quality is the mass of 1000 grains. The variation over the years ranged from 29.4 g to 37.7 g (CV = 9.4%). A low value of variability indicates a weak reaction of varieties to changes in external environmental conditions. It characterises the high resistance of oat varieties in various weather conditions of vegetation. External environmental conditions to a greater extent influenced the graininess of the grain (CV = 16.8%) and the lysine content in the grain (CV = 18.8%). On average, the conditions of the year affected the characteristics of the protein content in the grain (CV = 10.1%) and the nature of the grain (CV = 14.5%), which was due to the environmental fitness of the oat varieties for cultivation in the region.

Varieties of oats Marshal, Cardinal and Peredovik are the most stable in terms of aggregate quality indicators. The Marshall oats variety was characterized by a high and stable protein and lysine content. In the variety Peredovik, a high mass of 1000 grains and a full grain weight were noted. Over the years of research, the Cardinal oat variety had a low pitting and a large mass of 1000 grains. We recommend them for sustainable crops of high-quality grain for various food uses. We recommend them for sustainable crops of high-quality grain for various food uses.

References
[1] Toth J, Pandurangan A, Burt A and Kumar S 2019 Canadion J. of Planet Science 99 111–27
[2] Bilgin O, Guzman C, Basar I and Korkut K 2016 Crop Science 56 73–84
[3] Skripka O V, Samofalov A P, Pogorny S V and Gromova S N 2016 Achievements of Science and Technology of Al Cis 30 30–32
[4] Loskutov I G, Blinova E V, Gavrilova O P and Gagkaeva T Yu 2016 Vavilov J. of Genetics and Breeding 20 286–94
[5] Syukov V V, Zakharov V G and Menibaev A I 2017 Vavilov J. of Genetics and Breeding 21 534–36
[6] Galili G 2014 International J. of Molecular Sciences 3 437–42
[7] Gorash A, Frromiene R, Fetch Mitchell J, Liatukas Z and Danyte V Annals of Applied Biology 171 281–02
[8] Gavrilova O P, Gannnibal Ph B and Gagkaeva T Yu 2016 Agricultural Biology 51 111–18
[9] Pereira H S, Alvares R C, Silva F C, Faria L C and Melo L C 2017 Semina: Ciencias Agrarias 38 1241–50
[10] Admas S and Tesfaye K 2017 Acta Universitatatas Sapientiae. Agriculture and Environment 9 82–94
[11] Sibakov J 2014 Journal of Cereal Science 2 56–60
[12] Decker E A, Devin J and Rose D J 2014 British J. of Nutrition 112 58–64
[13] Dong J L, Yang M, Shen R L, Zhai Y F, Yu X and Wang Z 2019 *Food Sci. TechnoInt.* **25** 282–94
[14] Fritz R D and Chen Y 2018 *Nutrition Research* **60** 54–67
[15] Scholey D V, Marshal A and Cowan A A 2020 *Poultry Science* **99** 2566–72
[16] Ponomareva M L and Ponomarev S N 2019 *Vavilov Journal of Genetics and Breeding* **23** 320–27
[17] Mitrofanova O P and Khakimova A G 2016 *Vavilov Journal of Genetics and Breeding* **20** 545–54
[18] Loskutov I G, Shelenga T V, Konarev A V, Shavarda A L, Blinova E V and Dzubenko N I 2016 *Vavilov Journal of Genetics and Breeding* **20** 636–42
[19] Kriger O V, Kashirskikh E V, Basich O and Noskova S Yu 2018 *Foods and Raw Materials* **6** 47–55
[20] Thies F, Masson L F, Boffetta P and Ethort P K 2014 *British Journal of Nutrition* **112** 19–30
[21] Demina I F and Krivobochek V G 2018 *The Agrarian Scientific Journal* **3** 15–17
[22] Polonskiy V I, Loskutov I G and Sumina A V 2020 *Agricultural Biology* **55** 45–52