# ASSESSMENT OF THE ADAPTIVE POTENTIAL OF WINTER PEAS GENOTYPES BY GREEN MASS AND GRAIN YIELD

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**Abstract.** In a three-year field experiment conducted at the Institute of Forage Crops - Pleven (2016-2018) the adaptive potential of winter pea genotypes for green mass and grain yield was assessed. Five hybrid lines of winter peas with a different morphology of the compound leaf: No.12, No.13, No.14 - ordinary type (“AFAF-TLTL-STST”); No.6 - afila type (semi-leafless - "afaf-TLTL ST-ST"); No.9 - double recessive type "pleiofila" (tendril acacia) and variety Mir (control) were the subject of the study. The morphotype was found to affect the adaptive potential of genotypes. The greatest adaptability was found for genotypes with ordinary leaf type, followed by the double-recessive type of pleiophile. In terms of green mass yield, lines No.9 and No.13 were characterized by high general adaptive response (110%, 107%), high genetic flexibility (17.36, 17.76) and potential productivity (2007 kg/ha, 2059 kg/ha). The lines No.14 (195 kg/da), No.6 (195 kg/da) and No.12A (174 kg/da) have high grain productivity, coefficient of adaptability over 100%, high genetic flexibility (1.86, 1.65 and 1.65) and a high grain index (0.91, 0.62 and 0.85), which characterizes them as promising in the direction of grain production. The study aimed at to analyze winter forage pea lines to create new genotypes with increased adaptive potential in terms of green mass and grain yield.

**Key words:** pea; yield; genetical flexibility.

## INTRODUCTION

Increasingly observed changes in agrometeorological conditions adversely affect crop productivity. One of the main tasks of the selection is to evaluate the perspective selection samples for ecological adaptability. Research in this area were conducted in many crops: winter cereals [13, 17], spring cereals [22], soybeans [3, 9], peas [8, 19].

To increase the yield of peas - one of the main sources of protein, it is necessary to create varieties adapted to environmental conditions [14]. Moreover, there are huge differences between the productive potential and its realization in production conditions, due to the strong variation of the values of this indicator under different environments [23]. Combining in one genotype of high indicators of productivity and adaptability to the complex of abiotic and biotic environmental factors is a difficult task, the solution of which is possible by studying the collected genetic material, applying different methods and schemes of selection, complex study of created genotypes by a number of traits and properties [20, 25]. The evaluation of the selection material at the stage of creating varieties according to the indicators of adaptability will allow to create not only highly productive varieties, but also those with high ecological stability, which will reduce the risk of yield loss [7].

The study aimed at to analyze winter forage pea lines to create new genotypes with increased adaptive potential in terms of green mass and grain yield.

## MATERIAL AND METHODS

During three growing season (2016-2018), five hybrid lines of forage peas (No. 14, No. 6, No.12 A, No. 13 and No. 9) and Mir variety as a control were tested on the experimental field in the Institute of Forage Crop –Pleven , Bulgaria. The tested winter pea lines were with a different morphology of the compound leaf: No.12, No.13, No.14 - ordinary type (“AFAF-TLTL-STST”); No.6 - afila type (semi-leafless - "afaf-TLTL ST-ST"); No.9 - double recessive type "pleiophile" (tendril acacia). The experiment was performed by the method of long plots with a plot size of 10 m2 in six repetitions At the full bottom pods stage the green mass yield (kg/da), and at the technical maturity stage the grain yield (kg/da) were recorded.

The parameters: total adaptability (A1; A2) according to Valchinkov (1990) [27], grain index (B) according to the methodology of Taranenko and Yacishen (2014) [26] were determined. In order to obtain objective information about the adaptability of the varieties and lines of winter forage peas, the coefficient of the total adaptive response (Kar), calculated by the method of Zhivotkov et al. (1994) [28] was used. The method is based on the identification of the potential productivity and adaptability of the genotype in comparison with the general adaptive response of the samples to the growing conditions and refers to their average yield. The genetic flexibility parameter was calculated according to the method of Goncharenko (2005) [10].

Experimental data were statistically processed using the GENES 2009.7.0 computer software for Windows XP [2] and STATGRAPHICS Plus for Windows Version 2.1.

## RESULTS

Meteorological conditions for the study period are represented by the average daily air temperature and the amount of precipitation. The sowing of winter forage peas was carried out in early November. The study period is characterized by significant dynamics, especially in terms of the amount of precipitation. The amount of precipitation during the pea vegetation was

**Table 1.** Meteorological conditions during the pea growing season [Source: The National Institute of Meteorology anh Hydrology, Branch Pleven]

| Month | 2016 | | 2017 | | 2018 | |
|---|---|---|---|---|---|---|
| | Temperature, °C | Rainfall, L/m$^2$ | Temperature, °C | Rainfall, L/m$^2$ | Temperature, °C | Rainfall, L/m$^2$ |
| I | -0.05 | 97.8 | -4.0 | 41.3 | 2.2 | 30.9 |
| II | 8.9 | 4.0 | 3.0 | 16.2 | 2.2 | 72.0 |
| III | 8.5 | 76.6 | 10.3 | 62.1 | 5.3 | 98.1 |
| IV | 15.4 | 73.1 | 12.2 | 37.6 | 16.9 | 20.2 |
| V | 16.4 | 77.5 | 17.0 | 155.0 | 19.6 | 47.7 |
| VI | 23.0 | 45.8 | 23.0 | 44.8 | 21.8 | 155.2 |
| VII | 24.6 | 7.8 | 23.9 | 155.9 | 23.0 | 118.9 |
| VIII | 23.6 | 31.2 | 24.4 | 28.6 | 23.9 | 21.8 |
| IX | 19.4 | 61.8 | 19.5 | 37.4 | 18.9 | 15.4 |
| X | 10.8 | 53.8 | 12.6 | 108.9 | 13.6 | 16.1 |
| XI | 6.1 | 40.7 | 7.2 | 55.4 | 5.4 | 61.9 |
| XII | 1.1 | 14.4 | 5.0 | 50.6 | 1.2 | 30.6 |
| **Av/sum** | **13.1** | **584.5** | **12.8** | **793.8** | **12.8** | **688.8** |

highest in March 2016 (76.6 L/m$^2$), May 2017 (155.0 L/m$^2$) and June 2018 (155.2 L/m$^2$) (Table 1). The months of March and April characterized by a gradual rise in average monthly temperatures, which were slightly below normal but sufficient for the normal course of the phases of plant development. The good combination of temperature and rainfall in May and June 2016 has contributed to the favorable course of the last stages of plant development. The meteorological factors average daily air temperature and rainfall in May 2017 were in a favorable combination with each other and had a positive effect on plant productivity. A significant amount of precipitation fell in October 2017 (108.9 L/m$^2$) and November 2018 (61.9 L/m$^2$). Sufficient moisture storage and favorable daily temperatures were a good prerequisite for the joint germination of seeds and garnish of the crop during this period of the study. Year of 2018 started with positive average daily air temperatures for the months of January and February (2.3°C and 1.92°C), but with a very small amount of precipitation for the first month (30.9 L/m$^2$). In March the amount of precipitation is around and above the norm for the month (98.1 L/m$^2$). October 2018 was characterized by an insignificant amount of precipitation (16.1 L/m$^2$) and an average monthly temperature of 13.6 °C. At the same time, it should be noted that different genotypes respond differently to stressful situations of an abiotic nature. Essential for the formation of the productivity of legumes is the sufficient amount of moisture during the growing season and the required amount of active temperature.

### General adaptability and grain index

According to the values of the index "A" (A1 and A2) the lines differ in their adaptive capabilities. The highest values of total adaptability in green mass yield were distinguished by line No.13 and variety Mir, which suggests the existence of genetic potential for greater adaptability to various environmental stressors. Line No.9 was also characterized by good adaptability. The remaining lines of forage peas had lower parameters of general adaptability, which determines the presence of a narrower specific adaptability, as the lowest values are reported for line No.14 (Fig.1).

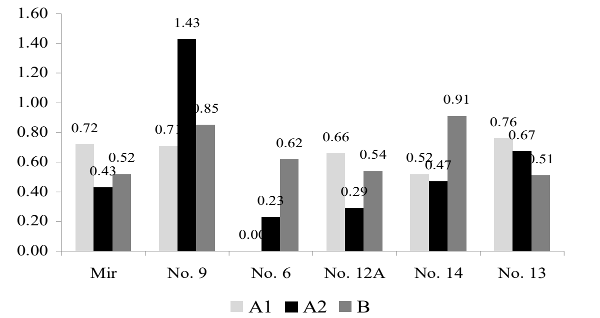


**Figure 1.** Total adaptability (A1 and A2) and grain index (B); A1 - by green mass yield; A2 – by grain yield; C - grain index.

The parameter for total adaptability in grain yield (A2) showed a certain superiority of line No. 9 over the other lines and variety Mir. The highly productive lines No. 14 and No.6 showed lower general adaptability and realize their productive potential under more specific environmental conditions. Line No.13 was characterized by good overall adaptability, despite the lower grain productivity.

Considering the grain index (B) as a selection criterion, in the determination of which the yields of green mass and grain were used, it can be noted that lines No. 14, No. 9 and No. 6 were defined as the most valuable in the direction of grain. Lines No.13 and No.12 combine high green mass yield and high adaptability over the years of research and can be successfully used in the direction for forage.

It should be have in a mind that these approaches to the classification of varieties and lines are to some extent relative. When using a larger part of samples from the working collection, the ranking of the genotypes can be changed, taking into account the biological characteristics of the lines and the different environmental conditions.

The results obtained showed that the purposeful change in the architecture of the genotype by changing the grain index (individual productivity of grain and green mass) can lead to a different ratio between the vegetative and generative mass of the plant. The change of habit is accompanied by a positive dynamics of the process of photosynthesis, and hence an increased outflow of assimilates from the vegetative to the generative parts of the plant and their more rational use during the period of grain formation.

### General adaptive response

In order to obtain objective information about the adaptability of the studied winter pea genotypes, the coefficient of total adaptive response for green mass and grain yield was calculated (Fig. 2 and 3). The obtained average coefficient of adaptability can be used to assess the productive capabilities of the studied lines and varieties.

The highest average yield of green mass (Fig. 4) was reported at line No.13 (2059 kg/da), followed by No.9 (2007 kg/da) and variety Mir (1916 kg/da), and No.14 realized the lowest yield of green mass (1514 kg/da).

The lines No.9 (110%), No.13 (107%) and variety Mir (102%) characterized by high adaptability and potential productivity. The lines No.12A and No.14 were found less adaptive with an adaptive response coefficient below the average for the group of studied lines and varieties ($K_{ar}$ <100%).

The lines No.14 (195 kg/da), No.6 (175 kg/da) and No.12A (174 kg/da) characterized by the highest grain yield (Fig. 5). The average yield for the other lines ranges from 124 kg/da (No.13) to 147 kg/da (No.9).

In our study, the overall adaptive response rate for the grain yield trait (Figure 3) ranged from 78% to 122%. During the years of study, three (No.6, No.12A and No.14) of the five lines had a coefficient of adaptability over 100%, exceeded one and showed the resistance of the variety to adverse meteorological

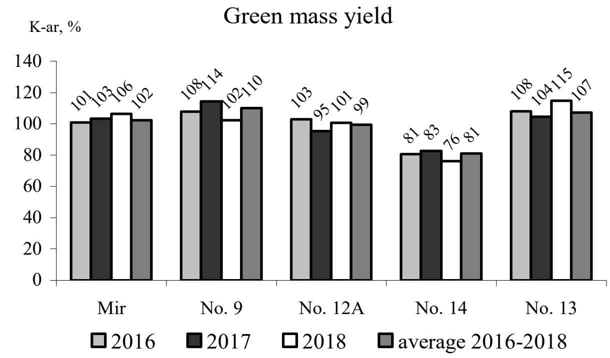


**Figure 2.** Coefficient of general adaptive reaction ($K_{ar}$) according to Zhivotkov et al. (1994) [28] for green mass yield of varieties and lines of winter forage peas

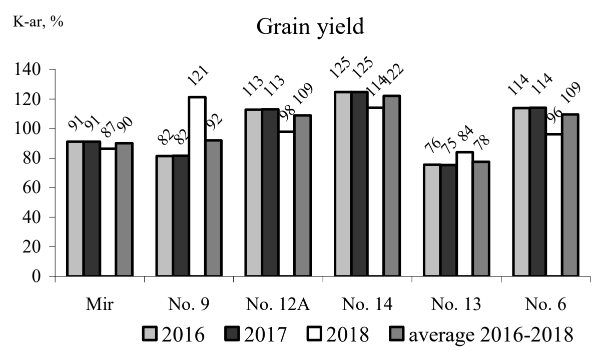


**Figure 3.** Coefficient of general adaptive reaction ($K_{ar}$) according to Zhivotkov et al. (1994) [28] for grain yield of varieties and lines of winter forage peas

conditions. In other words, they are able to give a stable grain yield, regardless of meteorological conditions. Variety Mir has a coefficient of adaptability of 90%, and line No.13 has a coefficient of adaptability of 78%, respectively.

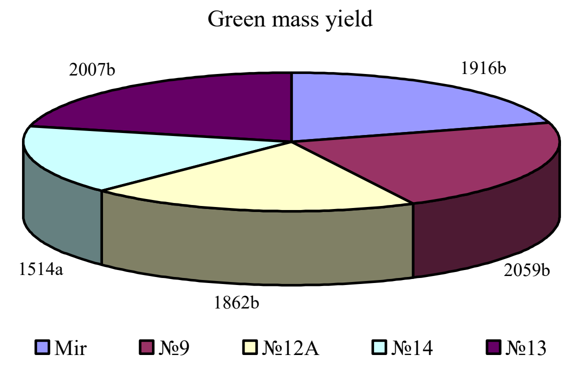


**Figure 4.** Green mass yield of varieties and lines of winter forage peas (a, b - statistically significant differences at P = 0.05)

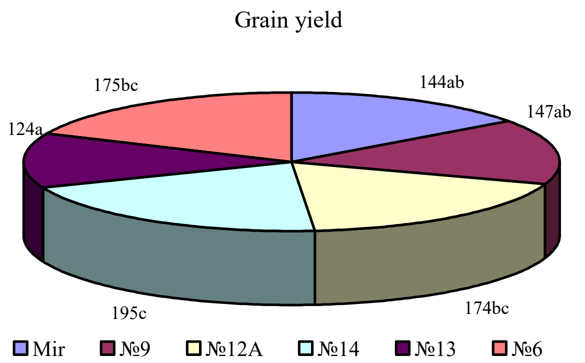


**Figure 5.** Grain yield of varieties and lines of winter forage peas (a, b, c - statistically significant differences at P = 0.05)

### Genetic flexibility

Priority should be given to selection aimed at specific adaptability, ensuring high genotype productivity against the background of adverse abiotic factors.

The average yield of varieties under contrasting (stressful and non-stressful) conditions characterizes their genetic flexibility. High values of this parameter indicate a greater degree of correspondence between the genotype (line) and environmental factors.

In terms of green mass yield, the lines No.13 and No.9 were characterized by high genetic flexibility with parameters 17.76 and 17.36, respectively (Fig. 6). According to this indicator, the remaining winter pea lines are classified in the following order: No.12A (16.67), Mir (16.55) and No.14 (12.97).

Genotypes with high genetic flexibility capable of forming grain yield under adverse meteorological conditions have been experimentally determined. In this respect, the lines No.14, No.6 and No.12A are of interest, where the coefficient of genetic flexibility was 1.86, 1.65 and 1.65. Line No.13 and variety Mir were characterized by lower genetic flexibility and less adaptability to grain yield. It should be noted that line No.12A confirms the average level of adaptability, both in terms of green mass yield and grain yield.

The study reveals that the intensity of new entry breeding forage pea genotypes should be considered as a combination of high potential productivity and yield stability, providing high resistance to various stressors.

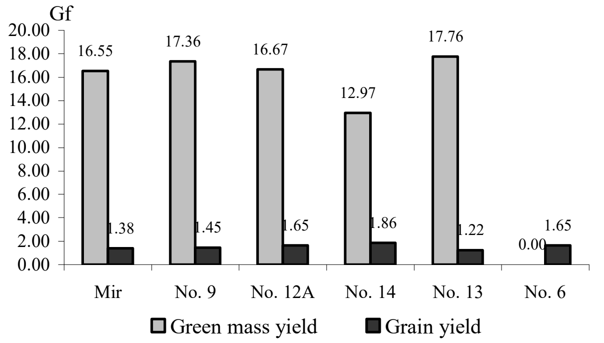


**Figure 6.** Coefficient of the genetic flexibility parameter (Gf) according to Goncharenko (2005) [10] for green mass and grain yield of varieties and lines of winter forage peas

## DISCUSSION

Some authors [1, 5] report in their research that the influence of the variety factor was significantly greater than that of the environmental factor, which has not been confirmed in our research. The authors were of the opinion that the selection progress of the pea varieties in the direction for grain has reached a level of 600 kg/da and the influence of the genotype factor was 60% of the total influence.

Our results partially support the conclusions reported by Filatova (2019) [22] in collection samples of peas. The author finds that varieties with ordinary leaf type have low ecological plasticity, but greater resistance to stress and homeostatic. Aphila morphotypes are characterized by a greater correspondence between the genotype and the environment in terms of adaptive response.

The conclusions of other authors [11] that in conditions of limiting environmental factors (drought) pea leaf forms are "more durable" than mustachios and allows them to form higher productivity are in line with the present study. The author adds that the decrease in yield of such genotypes in favorable years is mainly due to losses during harvest, as the leaf forms tend to lodging.

Putina and Besedin (2020) [21] in the evaluation of varieties of peas express the opinion that for the needs of ecological selection more complete information is needed about the studied samples in terms of adaptability, stability and plasticity. The authors found similar results to the study, but did not find a direct relationship between these parameters and the length of the growing season of individual genotypes.

However, in other crops, such as winter rye, some authors [2] report that later-maturing varieties were found more adaptable to growing conditions compared to early-maturing in a given ecological niche.

Based on the results of studies in winter wheat other researchers [15] noted that among the varieties evaluated by them in terms of a set of adaptability parameters there were those that combine high yield with good ecological stability and genetic flexibility. The authors report that in most of the studied varieties there is a discrepancy between high yield - stress resistance - genetic flexibility.

Some authors [12, 16, 18, 24], studying the problem of improving peas and taking into account global achievements and the discovery of new areas in the selection of this crop, believe that researchers should pay attention to the morphological characteristics of plants directly affecting productivity. In this regard were the studies, where were developed a new direction in the selection of peas in terms of resistance to cracking of pods based on mutation - deformation in the formation of lignin [4, 6]. The authors are of the opinion that the greatest effect in eliminating the negative from the point of view of production biological properties of peas would be achieved through the use of growth and leaf mutant forms in genotypes that increase the resistance to lodging and non-shedding of pods and cohesive maturation.

The results obtained are contribution to the selection process of winter forage pea in regard to the creation of genotypes with increased adaptive potential in terms of both green mass and grain yield.

The morphotype was found to affect the adaptability of genotypes. The greatest adaptability have the genotypes with ordinary leaf type, which is important for futher selection.

**Conflict of interest:** There is no actual or potential conflict of interest in relation to this article.

## REFERENCE

[1] Amelin, A.V., Chekalin, E.I., (2019): Adaptive abilities of pea plants and their changes as a result of selection. Grains and legumes, 2 (30): 4-13.

[2] Cruz, C.D., (2009): Programa Genes: Biometria, University of Federal Viçosa, Viçosa, Brazil, 382 p.

[3] Fadeev, A.A., Fadeeva, M.F., Vorobieva, L.V., (2011): Ecological resistance of early soybean varieties to abiotic stresses. Oilseeds. Scientific Practice Bulletin All-Russian Research Institute of Oilseeds, 2(148-149): 45-48.

[4] Fadeeva, A.N., (2012): Basic achievements and directions of breeding of peas in Tatar Research Institute of agriculture. Legumes and cereals, 1: 65-68.

[5] Fadeeva, A.N., (2020): New variety of pea (*Pisum sativum* L.) Frigate. Achievements of Science and Technology of Agro-industrial complex, 34 (3): 36-40.

[6] Fadeeva, A.N., Fadeev, E.A., Shurkhaeva, K.D., Abrosimova T.N., (2015): Results and prospects of pea breeding for resistance to pods opening. Achievements of Science and Technology of Agro-industrial complex, 5: 20-22.

[7] Filatova, I.A., (2019): Yield and ecological adaptivity of perspective pea varieties. Legumes and cereals, 4(32): 35-40.
[8] Filatova, I.A., (2016): Ecological plasticity and stability of varieties and cultivars of peas in the conditions of the Stone Steppe. Legumes and cereals, 3(19): 41-45.
[9] Fokina, E.M., Titov, S.A., Razantsei, D.R., (2019): Agroecological assessment of promising soybean samples. Achievements of Science and Technology of Agro-industrial complex, 33(7): 21-23.
[10] Goncharenko, A.A., (2005): On adaptability and environmental sustainability in varieties of crops. Bulletin of the RAAS, 6: 49-53.
[11] Kondykov, I.V., (2011): On priorities in pea breeding. Journal Orel GAU, 5(32): 96-103.
[12] Kondykov, I.V., Uvarov, V.N., Zelenov, A.N., Kondikova, N. N., (2012): Pea varieties of the new generation, contrasting in the architecture of the leaf apparatus. Agriculture, 5: 34-36.
[13] Konstantinova, O.B., Kondratenko, E.P., (2015): Yield and parameters of adaptability of new grades of winter rye in the conditions of a forest-steppe zone of the Kemerovo area. Achievements of Science and Technology, 29(3): 7-9.
[14] Korobova, N.A., Korobov, A.P., Kozlov, A.A., Lysenko, A.A., (2016): Ecological plasticity and yield of grain pea varieties. Achievements of Science and Technology, 30 (2): 85-88.
[15] Krivosheev, S.I., Shumakov, V.A., (2020): Evaluation of the varietal composition of winter wheat in kursk region on the parameters of environmental plasticity and stability. International Agricultural Journal, 5(377): 31-33.
[16] Lakić, Ž., Stanković. S., Pavlović, S., Krnjajic, S., Popović, V. (2019): Genetic variability in quantitative traits of field pea (*Pisum sativum* L.) genotypes. Czech Journal of Genetics and Plant Breeding, 55(1): 1-7.
[17] Mameev, V.V., Torikov, V.E., Nikiforov, V.M., (2014): Ecological stability and plasticity of winter crop varieties in the southwest of the Central region of Russia. Bulletin of the Bryansk State Agricultural Committee Academy, 6: 32-38.
[18] Mihailović, V., Vasiljević, S., Karagić, Đ., Milošević, B., Radojević, V., Popović, V., Đalović, I. (2019): The first Serbian cultivar of winter pea for grain, NS Mraz. Acta Agriculturae Serbica,doi:10.5937/AASer1947003M, 24(47): 3-11.
[19] Ponomareva, S.V., (2019): Ecological plasticity and stability of seed yield and green mass of field peas in the Volga-Vyatka region. Legumes and cereals, 2(30): 43-47.
[20] Pryanishnikov, A.I., Saifulin, R.F., Lyashcheva, S.V., (2015): Development of methods used in the selection process in adaptive crop production. Agrarian Scientific Journal, 10: 20-23.
[21] Putina, O.V., Besedin, A.G., (2020): Adaptive ability and stability genotypes of vegetable peas of different ripeness groups. Vegetables of Russia, 4: 45-49.
[22] Sapega, V.A., Tursumbekova, G.Sh, Sapega, S.V., (2012): Productivity and parameters of stability of grades of grain crops. Achievements of Science and Technology, 10: 22-26.
[23] Sapega, V.A., (2015). Yield and parameters of adaptive ability and stability of pea varieties. Russian Agricultural Science, 5: 14-17.
[24] Sinjushin, A., (2013): Mutation genetics of pea (*Pisum sativum* L.): what is done and what is left to do. Ratarstvo I Povratarstvo, 50(2): 36-43.
[25] Syukov, V.V., (2014): The direction of selection for productivity and adaptability: contradiction or consonance. VI Congress of the Vavilov Society of Geneticists and Breeders (VOGiS) and Associated Genetic Symposia: Abstracts. Rostov-on-Don: Institute of Cytology and Genetics, Russian Academy of Sciences, pp. 136.
[26] Taranenko, L.K., Yacishen, O.L., (2014): Physiological-genetic mechanisms of improvement of plant architectonics of buckwheat genotypes by means of index selection. Legumes and Cereals, 3(11): 53-60.
[27] Valchinkov, S., (1990): Method for classification of genotypes with relatively high and stable yield. Scientific works of VSI - Plovdiv, 35(4): 161-165.
[28] Zhivotkov, L.A., Morozova, Z.A., Sekatueva, L.I., (1994): Methods for identifying the potential productivity and adaptability of varieties and selection forms of winter wheat on the indicator "yield". Breeding and Seed Production, 2: 3-6.

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