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Research Article

Variability in the productivity of peanut accessions (*Arachis hypogaea* L.) at ecological-geographical testing

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ABSTRACT

BACKGROUND: Russia is one of the largest peanut-buying countries. At the same time, in the south of the country, a number of zones meet the requirements for the cultivation of peanuts.

AIM: Identification of a new source material for peanut breeding by the method of ecological and geographical testing of collection samples.

MATERIALS AND METHODS: The work used 30 of peanuts accessions from the VIR collection of various origins. To assess the stability of productivity, standard deviation (*s*), coefficient of variation (C_v) and regression (β_i) for environmental conditions according to Eberhart and Russell were used.

RESULTS: As a result of the study, the possibility of growing individual varieties of peanuts in the south of the RF under modern conditions was confirmed. It was determined that some samples are more productive and suitable as starting material for the conditions of the Krasnodar Territory (k-283, k-1157), others — for the conditions of the Astrakhan region (k-317, k-868). The accessions of the VIR collection were found to be more productive at 2 points experience, also marked as plasticity k-751, k-283, k-626, k-1533, k-1987.

CONCLUSIONS: In contrasting conditions (two geographical points for 3 years of study), peanuts accessions were identified that strongly react to changes in environmental conditions. Stable and plastic in productivity accessions can serve as the initial breeding material. It has been established that peanuts can be cultivated in the south of the Russian Federation, namely in the Astrakhan Region and the Krasnodar Territory.

Keywords: *Arachis hypogaea* L.; maturation of beans; variation; stability; starting material for selection.

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Научная статья

Изменчивость продуктивности образцов арахиса (*Arachis hypogaea* L.) при эколого-географическом испытании

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АННОТАЦИЯ

Актуальность. Россия входит в число крупнейших стран-покупателей арахиса. В то же время на юге страны ряд зон соответствует требованиям выращивания этой культуры.

Цель — выявление нового исходного материала для селекции арахиса методом эколого-географического испытания коллекционных образцов.

Материалы и методы. В исследовании находилось 30 образцов коллекции арахиса ВИР различного происхождения. Для оценки стабильности продуктивности применяли стандартное отклонение (s), коэффициент вариации (C_v) и коэффициент регрессии на условия среды по Эберхарту и Расселу (β_i).

Результаты. В результате исследования подтверждена возможность выращивания некоторых образцов арахиса на юге России в современных условиях. Одни образцы более продуктивны и пригодны в качестве исходного материала для условий Краснодарского края (к-283, к-1157), другие — для условий Астраханской области (к-317, к-868). Выявлены пластичные образцы: к-751, к-283, к-626, к-1533 из коллекции ВИР, в том числе сорта Стандарт, Отрадокубанский, отмеченные как более продуктивные в двух точках проведения опыта.

Выводы. В контрастных условиях (две географические точки за 3 года изучения) выявлены образцы арахиса, сильно реагирующие на изменения условий среды. Стабильные и пластичные по продуктивности образцы могут служить исходным селекционным материалом. Установлено, что арахис можно возделывать на юге России, а именно в Астраханской области и Краснодарском крае.

Ключевые слова: *Arachis hypogaea* L.; вызреваемость бобов; варьирование; стабильность; пластичность; исходный материал для селекции.

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ЭКО • ВЕКТОР

BACKGROUND

In Russia, an ecological and geographical network of experimental stations and a variety of testing plots is used to accelerate plant breeding rates and to create varieties and hybrids that have wider adaptive potential. The vast expanse of Russia and its diversity and conditions inevitably leads to the geographical approach to solving breeding problems [1]. Using this ecological and geographical network, the Vavilov All-Russian Institute of Plant Genetic Resources (VIR) can assess the potential yield and environmental resistance of a large number of promising plant varieties and identify donors for the most important traits: drought/cold tolerance and resistance to pathogens.

Climate warming has led to the northing of many crops [2, 3]. For example, southern oilseed crops, including *Arachis hypogaea* (peanut), are successfully cultivated in southern Russia (in the Krasnodar Krai and Astrakhan regions) [4]. *A. hypogaea* is a source of high-quality protein and fat. The seeds have 44%–56% and 22%–30% oil and protein contents, respectively [5, 6]. Peanut oil is one of the most commonly used edible vegetable oils and is used as a foodstuff (as a table condiment and in the canning industry). Peanut oil also has a wide range of industrial applications, including in the pharmaceutical industry. *A. hypogaea* as a row crop contributes to weed clearing from fields, while as a leguminous crop increases soil fertility when seeds are treated with nitrogen due to the assimilation of biological air nitrogen [7].

The first attempts to cultivate *A. hypogaea* in Russia date back to 1825; by 1940, *A. hypogaea* crops covered 231 km^2 of Russian land. Varieties including VNIIMK 344, VNIIMK 433, Spanish Improved, and Krasnodarets 14 were cultivated at the All-Union Research Institute of Oil Crops in Krasnodar, Russia. However, peanut cultivation and breeding in Russia stopped in the early 2000s [8]. Meanwhile, annual peanut imports to Russia exceed 100,000 tons [4].

A. hypogaea is a thermophilic, hydrophilic, heliophilous plant that demands fertility and looseness of the soil. Fertile, flat, sandy, and slightly clayey black soils that do not form crusts after rain are considered suitable for *A. hypogaea* cultivation [9]. The crop requires positive temperatures of 26°C–35°C. *A. hypogaea* is a plant of southern latitudes, as its minimum temperature for germination is 12°C–14°C. The crop can grow at air temperatures of up to 37°C–39°C, with an optimum growing temperature of 22°C–28°C [10, 11]. The critical water period comes during the mass flowering and fruiting stages. *A. hypogaea* is currently grown at latitudes between 40°N and 40°S, especially in areas with high rainfall. Two-thirds of the world's *A. hypogaea* are grown in areas with adequate rainfall, while the remaining are grown under irrigation [12].

The VIR collection contains 1,823 cultivated *A. hypogaea* accessions from 74 countries. All varieties described in the literature are represented in the collection. The varieties differ in productivity, seed and bean size, number of seeds in the bean, coloration of seed rind, taste [13], and fatty acid composition [14]. The use of global genetic resources of *A. hypogaea* will contribute to the revival of its cultivation in Russia.

Ecological and geographical tests allow investigation into the stability and plasticity of different varieties of *A. hypogaea*. Three main concepts of ecological stability exist. A genotype is considered stable if 1) the inter-medium variance is small, 2) the response to the medium is parallel to the mean response of all genotypes in the experiment, and 3) the residual error from regression on the mean index is small [15]. The creation of varieties with high productivity and the stable manifestation of this trait in different ecological conditions are important directions in modern plant breeding.

This study aims to identify new promising accessions as source materials for *A. hypo gaea* breeding in southern Russia based on the results of ecological and geographical tests and the study of the collection in Krasnodar Krai (VIR branch; Kuban Experimental Station [KES]) and Astrakhan (Lower Volga branch; Pre-Caspian Agrarian Federal Scientific Center of the Russian Academy of Sciences [PAFSC]).

MATERIALS AND METHODS

Ecological-geographical testing was conducted in the two locations (KES, Krasnodar Krai; 45.2N, 40.8E and PAFSC, Astrakhan: 46.3N, 44.3E), having contrasting climatic and soil conditions, to investigate economically valuable traits. The climate of the Astrakhan region is arid continental [16], while that at the experimental site of Krasnodar Krai is temperate continental [17]. KES is located in the steppe zone, which has black fertile soil. *A. hypogaea* can be grown here without irrigation. The PAFSC is located in the semi-desert zone, where soils are light brown and have different degrees of alkalinity. *A. hypogaea* is grown here under irrigation.

For ecological and geographical testing, 30 samples of the VIR collection were selected, which differed in geographical origin, variety, bean/seed morphology, and economically valuable features. The seeding of samples and analysis of traits were conducted according to the methodological guidelines for the study of peanuts (*Arachis hypogeea* L.) [13]. Three years of data (2019–2021) at two sites (six samples) were obtained. In this paper, the variability in productivity and maturation (one of the main traits productivity depends on) are discussed. The regionalized Otradokubansky variety was used as a standard.

Productivity (bean weight per plant) was calculated as the average of 10 plants per plot. Maturation was calculated as the percentage of developed (mature) beans on the plant using the following formula (1):

$$C = \frac{в}{a} \cdot 100, \quad (1)$$

where *C* is bean maturation of the sample, *a* is the total number of beans on one plant, and *в* is the number of mature beans on one plant.

Productivity traits were used to assess stability, i.e., standard deviation (*s*), coefficient of variation (C_v), and the Eberhart and Russell regression coefficient on medium conditions (β_i) [15, 18].

Eberhart and Russell (1966) [18] proposed a regression approach to estimate stability. The following model (2) is considered:

$$Y_{ij} = \mu_i + \beta_i I_j + \delta_{ij}, \quad (2)$$

where Y_{ij} is the average yield of the *i*-th variety in the *j*-th medium (*i* = 1, ... *v*; *j* = 1, ... *n*), μ_i is the average of the *i*-th variety across all mediums, β_i is the regression coefficient, which measures the response of the *i*-th variety to changing conditions, δ_{ij} is the deviation from regression of the *i*-th variety in the *j*-th medium, and I_j is the environmental index of the *j*-th medium, calculated by formula (3):

$$I_j = \frac{\sum_i Y_{ij}}{v} - \frac{\sum_i \sum_j Y_{ij}}{vn}. \quad (3)$$

The regression coefficient β_i is the first parameter of genotype stability:

$$b_i = \frac{\sum_j Y_{ij} I_j}{\sum_j I_j^2}. \quad (4)$$

The second stability parameter is the variance of the deviation from the regression line:

$$S_{d_i}^2 = \frac{\sum_j \hat{\delta}_{ij}^2}{n-2} - \frac{S_e^2}{r}, \quad (5)$$

where is the estimate of the pooled error and *r* is the number of repetitions. The sum of squares of deviations from the regression line is calculated by the below formula:

$$\sum_j \hat{\delta}_{ij}^2 = \left(\sum_j Y_{ij}^2 - \left(\sum_j Y_{ij}\right)^2 / n\right) - \\ - \left(\sum_j Y_{ij} I_j\right)^2 / \sum_j I_j^2. \quad (6)$$

Genotypes with $\beta_i = 1, S_{d_i}^2 = 0$ are considered stable.

The regression coefficient is a measure of phenotypic stability. If $\beta_i > 1$, the variety is considered to be highly sensitive to medium changes (stability is below average); if β_i is close to 1, the variety is moderately stable; when $\beta_i < 1$, stability is above average; if $\beta_i = 0$, the variety is absolutely phenotypically stable [19]. In this study, one-factor analysis of variance was used to compare the productivity in six media to show the contrasting climatic and soil conditions of two experimental sites in the Krasnodar Krai (KES) and Astrakhan (PAFSC) regions.

Maturation was analyzed using the non-parametric Kruskal–Wallis criterion, since values of this index were close to 100%.

Weather conditions for the experiment

The sources of meteorological data for PAFSC were Chernyi Yar meteorological station (World Meteorological Organization code 34578, 15 km from the experiment site) and KES, located in the fields of the Kuban station. In the experimental years, the mean sum of positive temperatures in PAFSC and KES were 38°C and 37°C, respectively. No significant differences were recorded between the observation sites ($p = 0.413$). Significant differences ($p = 0.018$) for the 3-year averages were observed for precipitation amounts. Thus, the average precipitation for the period with temperatures above 10°C was significantly lower in PAFSC (120 mm) compared to KES (387 mm; $p = 0.018$) (Fig. 1).

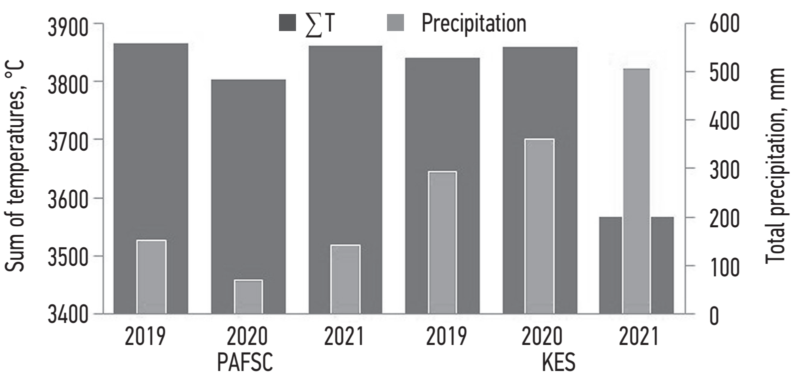

Fig. 1. The agrometeorological conditions of the experiment are the sum of positive temperatures above 10°C and the sum of precipitation for the period with temperatures above 10°C at the Kuban Experimental Station and at the Caspian Agrarian Federal Scientific Center of the Russian Academy of Sciences in 2019–2021

Рис. 1. Агрометеорологические условия эксперимента — сумма положительных температур выше 10 °С и сумма осадков за период с температурами выше 10 °С в Прикаспийском аграрном федеральном научном центре (ПАФНЦ) и на Кубанской опытной станции (КОС) в 2019–2021 гг.

RESULTS

Using one-factor analysis of variance, the factor «medium» (understood as 6 item/year combinations) was found to influence the productivity at a significance level of $p < 0.001$ (Fig. 2, Table 1). The highest average productivity (using Tukey's criterion) was at KES in 2019 (44.9 g/plant) and 2021 (41.6 g/plant) due to adequate rainfall in June. The productivity in the other variants was significantly lower: KES in 2020 and PAFSC in 2021, 2019, and 2020 amounted to 17.8 g/plant, 15.8 g/plant, 22.6 g/plant, and 27.5 g/plant, respectively. The productivity in KES was characterized by significant intervarietal variability. The average productivity in PAFSC and KES was 21.9 g/plant and 34.8 g/plant, respectively. However, the differences were not significant given the significant interannual variability ($p = 0.235$; Table 2). The productivity in PAFSC and KES did not correlate ($r = -0.02$; Fig. 3).

Experimentation under such contrasting conditions revealed genotypes that were plastic and stable in productivity (Table 3). Productivity is a highly variable trait. The regression coefficient (β_i) in medium conditions [formula (4)] ranged from –0.1 to 3.2 in the sample of 30 accessions. The residual variance of the regression on the median index $S^2_{d_i}$ [formula (5)] ranged from 3.1 to 1102.6, with an average of 115.8.

The most stable genotypes, according to Eberhart and Russell, have $\beta_i = 1$ and $S^2_{d_i} = 0$. According to the minimum coefficient of variation (C_v), k-178, k-24, k-1697,

Table 1. One-factor analysis of variance of the influence of six media on the productivity of 30 samples of peanuts

Таблица 1. Однофакторный дисперсионный анализ влияния шести сред на продуктивность 30 образцов арахиса

Indicator	*SS*		*df*		*MS*		*F*	*p*
	Effect	Error	Effect	Error	Effect	Error		
Productivity, g	22627.65	31382.07	5	174	4525.53	180.36	25.092	$5 \cdot 10^{-19}$

Table 2. One-factor analysis of variance of the effect of two points of the study on the productivity and ripeness of beans of peanut samples for 3 years of the study

Таблица 2. Однофакторный дисперсионный анализ влияния двух пунктов исследования на продуктивность и вызреваемость бобов образцов арахиса за 3 года исследования

Indicator	*SS*		*df*		*MS*		*F*	*p*
	Effect	Error	Effect	Error	Effect	Error		
Productivity, g	247.65	506.61	1	4	247.65	126.65	1.955	0.235

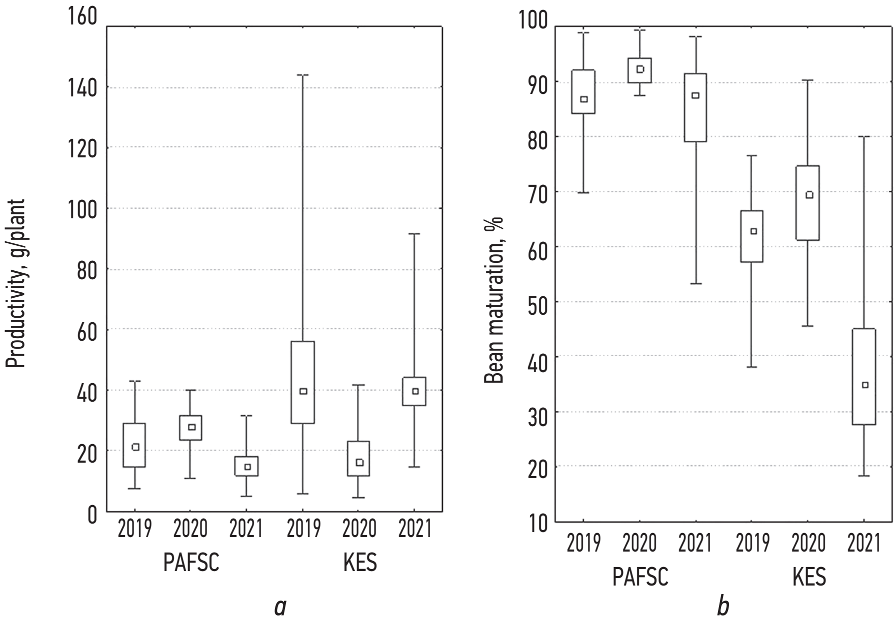

Fig. 2. Agrobiological indicators of 30 samples of peanuts grown at the Caspian Agrarian Federal Scientific Center and at the Kuban Experimental Station in 2019–2021: *a* — productivity; *b* — ripening of beans. Shown are: minimum, maximum values, quantiles, median

Рис. 2. Агробиологические показатели 30 образцов арахиса при выращивании в Прикаспийском аграрном федеральном научном центре (ПАФНЦ) и на Кубанской опытной станции (КОС) в 2019–2021 гг.: *a* — продуктивность; *b* — вызреваемость бобов. Показаны: минимальное, максимальное значения, квартили, медиана

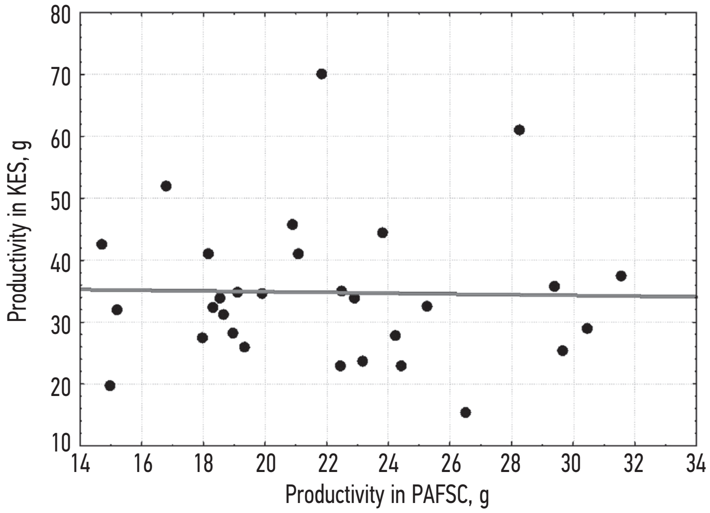

Fig. 3. Correlation of productivity of peanut samples at the Kuban Experimental Station (CBS) and at the Caspian Agrarian Federal Scientific Center (PAFSC). Solid line — regression line

Рис. 3. Корреляция продуктивности образцов арахиса на Кубанской опытной станции (КОС) и в Прикаспийском аграрном федеральном научном центре (ПАФНЦ). Сплошная линия — линия регрессии

k-300, k-175, k-793, k-433, and k-179 genotypes can be considered the most stable.

Samples that respond strongly to the environmental conditions have high β_i values. These included eight samples in the upper quartile of the distribution with a β_i between 1.3 and 3.2: k-283, k-1533, k-46, k-1157, k-626, k-1987, and k-41. Of these, some showed a tendency to high productivity (k-1987, the Otradokubansky standard variety) in KES. Such genotypes perform better in a narrow range of favorable media but reduce yield when deviating from the narrow optimum zone [15, 20–22].

The differences in maturation among the six media were significant ($p < 0.001$). In addition, significant item differences were observed across the three years of the study ($p = 0.032$), which averaged 88.2% in PAFSC and 55.7% in KES. The high maturation rate in PAFSC was probably due to the irrigated cultivation and the mechanical composition of loamy soils in this region since peanut bean maturation occurs in the ground (after flowering, the gynophore is formed, which helps the embryo to move underground). The highest maturation was observed at both sites in 2020 (Table 3), which was associated with the lowest rainfall during the ripening period, in August–October (Fig. 1).

Bean maturation was 92.5% in 2020 in PFASC, which was not significantly different from 2019 (86.9%), but higher than the values from all experimental years in KES (61.6%, 66.8%, and 36.7% in 2019, 2020, and 2021, respectively). No significant differences between samples in either KES ($p = 0.997$) or PAFSC ($p = 0.226$) were found in terms of maturation. However, the samples that show the best values in a given experiment may be suggested as the most promising (Table 4).

In PAFSC, the maturation rate (85.1%–92.5%) was higher in all years than in KES (36.7%–68.8%). High results in PAFSC (over 90%) were observed for k-3, k-24, k-175, k-283, k-300, k-317, k-416, k-626, k-793, k-903, k-939, and k-1533 samples. The coefficient of variation of this trait was lower in PAFSC. High maturation at two study points was observed for the following accessions: k-3 (USA), k-175 (Brazil), k-300 (Transvaal), k-317 (Southern Rhodesia), k-626 (India), k-793 (Russia), and k-1533 (Madagascar).

DISCUSSION

This paper presents data on the study of plasticity and stability of the productivity of peanut collection samples using the Eberhart and Russell method [18]. Experimentation under contrasting conditions (two geographical locations in 3 years of study) allowed the identification of plastic and stable genotypes in terms of productivity. Stability in productivity is a significant breeding trait. The eight most stable peanut samples were identified as k-24 (Uzbekistan), k-175 (Brazil), k-178 and k-179 (USA), k-300 (Transvaal), k-433 (Senegal), k-793 (Russia), and k-1697 (Vietnam). Accessions that were found to be strongly responsive to medium conditions were k-41 and k-46 (USA), k-283 (Uzbekistan), k-626 (India), k-1157 (Cameroon), k-1533 (Madagascar), and k-1987 (Otradokubansky, Russia). The plasticity of the following varieties was identified: k-283 (Uzbekistan), k-626 (India), k-751 (Portugal), k-1533 (Madagascar), and k-1987 (Otradokubansky, Russia). Variety plasticity is defined as the property to form a satisfactory yield under different growing conditions.

Grains, legumes, and other crops were used to study ecological plasticity and stability according to the method of Eberhart and Russell [18]. The study by Belyavskaya et al. [23] presents the analysis of the ecological

Table 3. Productivity stability of peanut samples at different points of the study
Таблица 3. Стабильность продуктивности образцов арахиса в разных пунктах исследования

Catalog No.	Origin	Productivity			C_v, %	β_i	$S^2_{d_i}$
		PAFSC	KES	average			
53	USA	14.9 ± 1.9	19.9 ± 7.2	17.4 ± 3.5	49.3	–0.1	91.4
868	Uganda	29.4 ± 3.3	35.9 ± 3.8	32.6 ± 2.7	20.0	0.0	53.1
1026	Mali	26.5 ± 5.9	15.5 ± 3.9	21.0 ± 4.0	46.7	0.1	118.6
317	Zimbabwe	29.6 ± 5.7	25.5 ± 7.6	27.6 ± 4.3	38.5	0.2	131.7
319	Uzbekistan	19.3 ± 5.7	26.1 ± 2.6	22.7 ± 3.2	34.4	0.4	39.7
416	Argentina	22.4 ± 6.6	23.1 ± 5.2	22.8 ± 3.8	40.4	0.4	80.8
1547	Madagascar	22.9 ± 10.0	34.0 ± 4.0	28.4 ± 5.4	46.7	0.5	170.2
903	Tanzania	24.4 ± 4.9	23.1 ± 6.3	23.7 ± 3.6	36.7	0.5	45.1
939	Brazil	23.1 ± 8.5	23.8 ± 6.9	23.5 ± 4.9	51.3	0.6	104.2
354	Uzbekistan	17.9 ± 4.0	27.6 ± 7.7	22.8 ± 4.4	48.0	0.7	62.8
3	USA	18.9 ± 5.1	28.3 ± 7.4	23.6 ± 4.5	46.9	0.7	62.3
178	USA	25.2 ± 6.6	32.7 ± 6.3	29.0 ± 4.4	37.2	0.8	27.3
1027	Mali	30.4 ± 7.8	29.1 ± 14.7	29.8 ± 7.4	61.2	0.8	281.7
24	Uzbekistan	15.2 ± 4.7	32.2 ± 6.2	23.7 ± 5.1	53.4	0.9	39.9
1697	Vietnam	19.1 ± 3.2	34.9 ± 7.1	27.0 ± 4.9	44.9	0.9	25.8
300	Transvaal	18.6 ± 7.2	31.3 ± 7.6	25.0 ± 5.5	53.7	1.0	52.8
175	Brazil	22.5 ± 1.9	35.1 ± 11.3	28.8 ± 5.9	50.0	1.0	84.3
793	Russia	31.5 ± 2.0	37.6 ± 13.0	34.6 ± 6.0	42.9	1.0	89.5
433	Senegal	18.3 ± 3.2	32.5 ± 9.0	25.4 ± 5.3	51.2	1.1	3.1
202	Northern Manchuria	23.8 ± 2.6	44.6 ± 11.9	34.2 ± 7.1	51.2	1.1	134.2
597	Canada	24.2 ± 7.8	27.9 ± 11.8	26.1 ± 6.4	59.8	1.1	75.3
179	USA	19.9 ± 3.0	34.8 ± 10.5	27.3 ± 5.9	52.9	1.2	7.8
283	Uzbekistan	14.7 ± 2.4	42.7 ± 8.8	28.7 ± 7.5	63.8	1.3	84.5
1533	Madagascar	18.1 ± 4.8	41.2 ± 14.8	29.7 ± 8.7	71.4	1.5	107.7
751	Portugal	20.9 ± 3.4	45.9 ± 11.3	33.4 ± 7.7	56.4	1.5	29.6
46	USA	18.5 ± 7.3	34.0 ± 14.5	26.2 ± 8.0	75.1	1.6	25.9
1157	Cameroon	16.8 ± 6.8	52.1 ± 9.5	34.4 ± 9.5	67.3	1.7	109.3
626	India	21.1 ± 4.4	41.2 ± 16.9	31.1 ± 9.0	70.8	1.7	68.6
1987	Russia	28.2 ± 0.6	61.1 ± 25.0	44.7 ± 13.4	73.5	2.5	163.5
41	USA	21.8 ± 5.6	70.2 ± 37.4	46.0 ± 20.1	106.9	3.2	1102.6

Note. KES, Kuban Experimental Station; PAFSC, Pre-Caspian Agrarian Federal Scientific Center; C_v, coefficient of variation; β_i, regression coefficient of productivity for the study medium; $S^2_{d_i}$, residual variance of regression for the medium index. Samples were sorted in ascending order of β_i.

Table 4. The maturation of peanut samples (%) in contrasting climatic conditions at different points of the study in 2019–2021

Таблица 4. Вызреваемость образцов арахиса (%) в контрастных климатических условиях в разных пунктах исследования в 2019–2021 гг.

Catalog No.	Origin	PAFSC		KES	
		average	C_v, %	average	C_v, %
3	USA	92.7 ± 3.4	6.4	64.0 ± 10.0	27.2
24	Uzbekistan	91.0 ± 1.7	3.3	46.8 ± 13.9	51.5
41	USA	81.5 ± 6.0	12.7	47.8 ± 5.5	20.1
46	USA	83.5 ± 5.0	10.5	46.5 ± 1.9	7.2
53	USA	86.6 ± 3.7	7.4	56.2 ± 8.8	27.2
175	Brazil	95.3 ± 3.4	6.1	56.1 ± 4.8	14.7
178	USA	83.5 ± 6.0	12.4	47.9 ± 14.8	53.5
179	USA	86.5 ± 4.5	9.0	58.3 ± 11.9	35.2
202	Northern Manchuria	78.9 ± 5.4	11.8	60.5 ± 12.2	35.0
283	Uzbekistan	91.4 ± 2.6	4.9	54.0 ± 15.5	49.8
300	Transvaal	95.3 ± 2.2	4.0	64.4 ± 17.9	48.1
317	Southern Rhodesia	90.1 ± 1.1	2.0	62.1 ± 6.2	17.2
319	Uzbekistan	86.4 ± 3.1	6.2	61.9 ± 11.9	33.2
354	Uzbekistan	86.1 ± 1.9	3.8	54.8 ± 13.6	43.1
416	Argentina	90.8 ± 3.0	5.8	47.9 ± 12.1	43.6
433	Senegal	88.5 ± 4.1	8.0	55.3 ± 13.9	43.4
597	Argentina	80.7 ± 13.8	29.5	68.3 ± 4.6	11.7
626	India	92.5 ± 3.5	6.6	60.3 ± 18.1	52.0
751	Portugal	79.3 ± 4.6	10.1	49.4 ± 15.3	53.8
793	Russia	94.6 ± 1.3	2.4	59.7 ± 9.9	28.8
868	Uganda	88.9 ± 1.0	2.0	63.6 ± 14.1	38.5
903	Tanzania	91.9 ± 2.4	4.4	56.9 ± 17.0	51.7
939	Brazil	91.2 ± 3.3	6.4	53.5 ± 12.5	40.5
1026	Mali	89.6 ± 4.1	8.0	52.7 ± 6.1	20.0
1027	Mali	86.2 ± 5.3	10.7	51.3 ± 10.4	35.1
1157	Cameroon	85.4 ± 3.5	7.1	56.9 ± 9.6	29.2
1533	Madagascar	92.4 ± 0.5	0.9	56.5 ± 9.9	30.3
1547	Madagascar	88.6 ± 0.4	0.8	56.8 ± 17.5	53.5
1697	Vietnam	86.7 ± 2.6	5.3	51.8 ± 9.6	32.0
1987	Russia	88.6 ± 3.0	5.8	48.0 ± 7.1	25.6

Note. Average indicators for 3 years are given. KES, Kuban Experimental Station; PAFSC, Pre-Caspian Agrarian Federal Scientific Center

plasticity of soybean, according to Eberhart and Russell, using regression coefficients in different climatic conditions of Ukraine, which allowed the determination of the regions that are most favorable for growing new varieties. Biktimirov and Nizayeva [24] studied the ecological plasticity and stability of grain sorghum yield in the Pre-Ural steppe of the Republic of Bashkortostan. The experiments were conducted at the same growing site, but in different years (2015–2019). The meteorological conditions in the experimental years concerning temperature and water regimes were different, which allowed us to assess the lines under contrasting cultivation conditions. Based on a comprehensive assessment of ecological plasticity and stability, high-intensity varieties characterized by stable yields were identified. Using the same methods [15, 18], plasticity and stability parameters for yield and productivity of spring barley varieties in the conditions of the Non-Black Earth zone in Moscow and Ryazan regions were estimated [25]. The data were used to identify barley varieties with stronger responsiveness to changing conditions and varieties with low responsiveness to improved growing conditions. The stability of significant breeding traits of oat and barley samples has been studied in contrasting growing conditions of St. Petersburg and Tambov Region [22].

CONCLUSIONS

Our findings reveal that the southern regions of Russia, particularly the Astrakhan Region and Krasnodar Krai, are suitable for peanut cultivation. Peanut samples that are more productive in the Astrakhan and Krasnodar Krai regions were identified. Samples k-317 and k-868 were recognized as the most productive in PAFSC, while samples k-283 and k-1157 showed high productivity in KES. Yields are more stable on irrigated lands; however, the productivity of individual samples is greater in more fertile soils of Krasnodar Krai. The higher moisture of KES contributed to lower bean maturation, while the productivity did not differ significantly. The productivity of KES peanut samples in 2019 and 2021 reached significantly higher values compared to the other media studied and was characterized in these years by a large range of variability among samples.

Productivity-stable genotypes, which may serve as a source material for selection of new domestic varieties of peanut, were identified in this study. The identified genotypes were k-24 (Uzbekistan), k-175 (Brazil), k-178, k-179 (USA), k-300 (Transvaal), k-433 (Senegal), k-793 (Russia), and k-1697 (Vietnam).

ADDITIONAL INFORMATION

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