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Research Article

Morpho-yield contributing traits and correlation of soybean parental and F1 hybrids

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Abstract

This article presents the research outcome of studies based on the screening for productivity traits of soybean's genetic and botanical collection samples, the productivity indicators of the parental forms selected for cross-breeding, analysis of the correlation between them, and heredity in the F_1 species. The study results show a strong positive correlation between the number of pods per plant, the number of grains per plant, and grain weight. In contrast, the weight of 1000 grains is moderately positively correlated with the weight of grains per plant, while it displayed a weak positive and negative correlation with other species. In the F_1 hybrid generation, it was found that the studied fertility traits were mostly incompletely positive and highly dominant.

Keywords: legume, soybean, collection, yield, correlation, grain, F1 hybrids

Introduction

Today, soybeans are grown on a large scale worldwide, on over 200 million hectares. Soy is grown in more than 60 countries on Earth. The United States has about 50% of the cultivated area and more than 60% of the world's soybean production. 14 million are grown in China, and 7.5 million in Brazil, South America, Canada, Australia, and Western Europe. Soybean oil is the first and is 32.8%, and sunflower oil is 17.1% among the vegetable oils produced for consumption worldwide. Today, soybeans are grown on 122 million hectares in many world countries. In terms of cultivated area, it ranks 4th after wheat, rice, and corn worldwide (Khudaikulov & Atabaeva, 2021; Kurbanbaev *et al.,* 2023). Soy contains 30-45% protein, 17-26% fat, and about 2% various substances, up to 5% mineral salts, together with 12% essential vitamins. Soybean oil is used in food, medicine, and many fields of technology (Bashkatov *et al.,* 2019).

Soybean's larger growing areas in various countries might be due to the nutritious qualities of its grain and green mass, which can be used in food, feed, technical, and medical fields (Sichkar, 1987). Based on the soybean genotypes and environmental conditions, its grain oil and protein vary from 17-26% and 30-55%, respectively. The soybean grain also contains carbohydrates (20–25%), macro- and micro-elements including Ca, P, K, Na, Mo, (4–5%), and I and vitamins (E, B_1, B_2, B_6) (Nesterin & Skurikhin, 1979). Soybean is considered one of the main crops in the by-product of food protein, oil, cottonseed meal, and forages, and more than one thousand products are obtained (Sichkar, 1987). According to the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), over 840 million people are undernourished. In addition, more than 30% of the world's population suffers from malnutrition and lack of the most basic trace elements and vitamins, which clearly shows how relevant the issue of food security is. The population's need for food has posed several contemporary issues for the food industry because of the rapid population growth of Uzbekistan, which the world has also enhanced. These are providing the population with environmentally friendly agricultural products, improving the fodder base of animal husbandry, and organizing the rational use of land and water resources (Khudaikulov & Atabaeva, 2021).

It is also a well-known fact that agriculture, the food industry, animal husbandry, and poultry farming are essential sectors of the economy of our republic. According to the State Committee of the Republic of Uzbekistan on Statistics, dated October 01, 2022, the permanent residents are 35.8 million in the republic. Therefore, providing the population with high-grade food is an urgent issue that must be well addressed. Based on this, developing the above essential agriculture sectors of the economy is one of the current issues. Soybean is a leguminous crop that has been cultivated since ancient times, and the origin of cultivated soybean can be traced back to natural and artificial selections of the wild soybean species (Silva *et al.,* 2015). Cultivated soybean (Glycine max (L.) Merr.) is an annual leguminous plant. The stem is strong and grows upright. Some varieties branch strongly and grow up to 2 m in height. Most plant varieties are in the 60-90 cm range. It is divided into three types according to the growth characteristics of the stem.1) Incomplete type of growth (indeterminate). 2) Intermediate (semi-determinant), 3) Full-grown (determinant), this type is more typical of low-growing early plants. The growth type of soybean plants is of great importance. Because it greatly impacts the ability to grow the variety (Fomenko *et al.,* 2015).

Soybean flowers are collected in small, spiky inflorescences. The flowers are on the top of the stem, on the branches, in the axils of the leaves. The number of flowers is from 2-4 to 25 and more. The petals are white or purple. Pollination takes place in a closed flower bed. The duration of flowering on the main stem is 15-40 days or more depending on the genotype of the plant

(Sozonova, 2019). According to FAO (2004), increasing the yield, oil and protein content of soybeans is the basis of the main common program. Other economic characteristics of soybeans also influence changes in the above characteristics (FAO, 2004; Malik *et al.,* 2006). Several scientific studies have been conducted by our local scientists on the physiological and biochemical parameters of the soybean plant, including the amount of chlorophyll, the amount of protein and moisture content of the soybean grain, as well as the importance of soybeans in increasing soil fertility (Abdurazakova *et al.,* 2020; Juraeva *et al.,* 2020; Qulmamatova, 2023)

Improvement of selection processes plays an important role in increasing productivity. Statistical analysis of the correlation between the characters ensures productivity, and it is widely used in selection processes. For this reason, valuable farm signs and their interrelationships were studied in soybean collection samples. It is important to study the correlation between traits when simultaneous selection or low heritability of a trait is observed, allowing the establishment of effective selection criteria (Hamawaki *et al.,* 2012; Qulmamatova *et al.,* 2022). The correlation coefficient is used to test the correlation between variables. The coefficient r only estimates the coefficient of the relationship (direction) between the traits (El-Mohsen *et al.,* 2013). In grain yield selection processes, genotypic correlation is superior to phenotypic correlation, and environmental effects are not considered (Machikowa & Laosuwan, 2011). It is essential to analyze the relationship between the yield characteristics of the parental forms selected for nurturing based on screening the soybean genetic and botanical collection samples available in the institute. To select parental forms, crossbreed varieties with high economic features and indicators, productivity signs, oil and protein content were first studied and the correlation of features was statistically analyzed. It provides an opportunity to analyze how reliable the correlation is and how important the correlation between the studied characters is, to make the right decision when choosing parenting forms.

Material and methods

The field experimentation transpired from 2022 to 2023 at the Dormon Scientific Experimental Station, Institute of Genetics, Academy of Sciences, District Kibray, Tashkent region, Uzbekistan. From a botanical collection of 11 varieties (Sochilmas, Genetic 1; Selection 302, Ehtiyozh, Nena, and Tomaris) and F1 hybrids were selected, 2м^2 plots were planted and plant height, number of joints, plant branching, the number of pods per plant, grain weight per plant, number of grains per plant, and 1000 grain weight were studied.

Experimental conditions and statistical analysis

The soil samples, taken before the research at the Dormon Scientific Experimental Station, had the agrochemical properties of the typical gray and irrigated soil determined in the Kibray region (Table 2). The significant elements established in the soil were nitrogen (0.098%), phosphorus

(0.176%), potassium (0.58%), and humus (1.720%). All the experiments had three replications, with the results analyzed using Fisher's multivariate test of variance (ANOVA). The significance level calculation was between $P < 0.05$ and $P < 0.01$ (Steel & Torrie, 1984). Correlation coefficients were calculated using the formulae given by Kown and Torrie (1964).

Table 2. Agrochemical properties of a typical gray and irrigated soil of the Kibray region.

Soil	Active form, mg/kg		$N\text{-}NO_3$, mg/kg	General, %		N, %	Humus, %	C, %
	P_2O_5	K_2O		P_2O_5	K_2O			
Typical gray soil	28.06	368.00	50.18	0.176	0.58	0.098	1.720	0.998

The dominance coefficient in F1 hybrids determination was, according to Griffing (1950):
hp = (F1-MP) / P-MP
Where:
hp – dominance coefficient;
F_1 – the evaluated arithmetic mean of the hybrid;
MP – the evaluated arithmetic mean of both parents;
P – the evaluated arithmetic mean of the best parents

Results

According to the general analysis of the studied varieties, the plant height of the samples is an average of 124.95 cm. The lowest indicator is the Genetic one variety, 60.5±0.24 cm, and the plant height is 178.0±0.95 cm in the Ehtiyozh variety. The Genetic one variety is characteristic of the determinant type and is characterized by precociousness. Ehtiyozh is characterized by late ripening and indeterminate type (Table 1). The higher the height of the plant is, the higher the number of joints is. The number of limbs in a plant is often proportional to the height of the plant. The pod formation occurs at each limb in a plant. Considering this, up to 1-15 pods appear in one joint. It was 34.8±0.98 in the Genetic-1 variety. The number of grains produced per plant was from 100 to 150 grains.

In studied samples of the soybean plant, the number of pods per plant was 59.91 pieces, the number of grains per plant was 145.89 pieces, the weight of grain per plant was 23.38 g, and the weight of 1000 pieces of grain was 157.47 g. It was determined that the period from planting to ripening is 85 to 145 days. The correlation between them was also determined. The obtained F1 plants were studied for plant height, number of limbs per plant, number of pods and grains per plant, and 1000 grain weight. In soybeans, stem length is one of the important morphological characteristics. The length of the main stem is of great importance in increasing productivity, and this character is directly related to lodging resistance and planting agrotechnics. The length of the plant in the parent forms is 60.5 cm (Genetic 1) from 178 cm (need)in hybrid combinations in F1 generation hybrids. It was observed from 90.4±0.25 (Sochilmas x Genetic) cm. to 151.11±3.55 (Ehtiyozh x To'maris). When analyzing the types of heredity of this character, in 3 of the 8 combinations studied, Sochilmas x Genetic 1 and To'maris

Table 1. Morpho-yield contributing traits and correlation of soybean parental and F1 hybrids

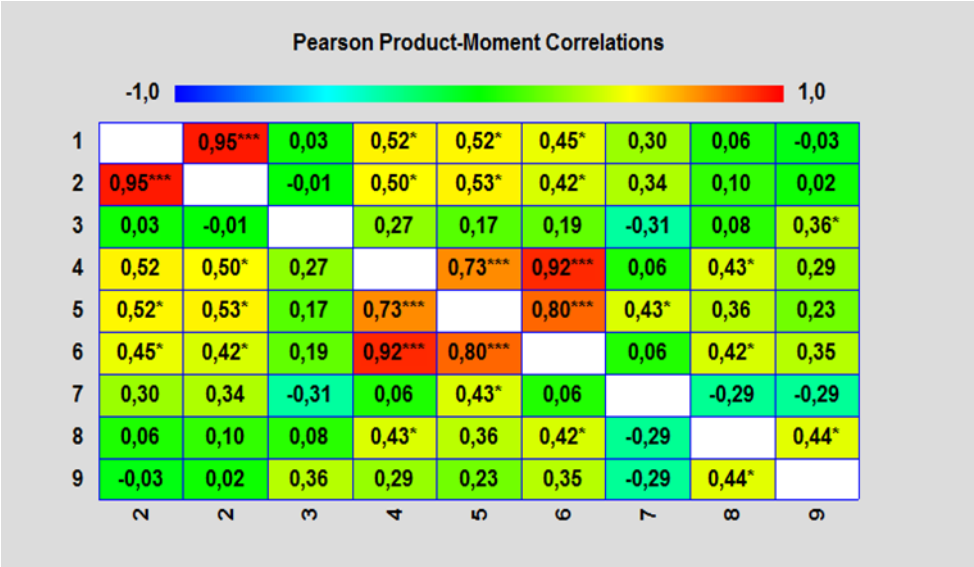
Parent	**Plant height, cm**		**Number of pods, pcs**		**The number of grains per plant, pcs**		**Grain weight per plant, g**		**Weight of 1000 grains, g**	
Sochilmas	85.5±0.66		60.0±1.31		149.7±2.95		23.04±0.45		154.0±0.01	
Genetic 1	60.5±0.24		34.8±0.98		89.4±2.45		11.65±0.34		129.7±0.02	
Selection 302	138.0±0.39		60.0±0.66		96.5±1.0		13.48±0.14		139.7±0.01	
Ehtiyozh	178.0±0.95		74.3±1.84		183.2±4.5		31.75±2.94		130.7±0.14	
Nena	102.5±0.64		56.9±0.56		142.2±2.02		15.02±0.21		100.5±0.06	
Tomaris	95.0±0.71		60.2±0.95		131.9±1.39		21.17±0.45		160.7±0.01	
Hybrids	**Plant height, cm**		**Number of pods, pcs**		**The number of grains per plant, pcs**		**Grain weight per plant, g**		**Weight of 1000 grains, g**	
	F1	hp	F1	hp	F1	hp	F1	hp	F1	hp
Sochilmas x Genetic-1	90.4±0.25	1.4	144.4±1.15	7.7	308.2±5.39	6.3	35.82±0.46	3.2	118.4±0.11	-1.7
Sochilmas x Selekta 302	108.75±1.55	-0.1	79.5±2.19	19.5	257.75±16.38	5.1	30.76±2.03	2.6	117.4±0.13	-4.1
Ehtiyozh x Tomaris	151.11±3.55	0.4	209.33±25.09	20.2	482.56±59.43	12.7	75.36±10.05	9.2	157.7±0.17	-6.1
Ehtiyozh x Nena	142.0±0.67	0	191.6±2.5	14.5	448.±1.97	13.9	73.83±1.62	6	157.1±0.11	2.3
Genetic-1 x Sochilmas	92.60±0.77	1.6	142.8±1.42	7.6	331.4±3.29	7	39.24±0.20	3.8	118.6±0.61	-1.9
Selecta 302 x Sochilmas	122.4±0.55	0.4	105.4±1.75	45.4	241.6±4.07	4.5	30.51±0.41	2.6	126.7±0.93	-2.8
Tomaris x Ehtiyozh	139.0±1.12	10.7	155.4±1.57	12.5	349.8±2.72	41.3	50.87±0.33	4.6	145.5±0.72	-0.4
Nena x Ehtiyozh	121.0±0.41	0.5	134.4±1.29	7.9	308.6±2.92	7.1	33.71±0.27	1.2	109.5±1.15	-0.8

x Ehtiyozh, A state of dominance with positive heterosis was observed in the Genetic 1 x Sochilmas hybrid combinations. In the Sochilmas x Selekta 302 hybrid combination (hp=-0.1), a negative incomplete dominance condition was observed, and it was found that the character was inherited towards the Sochilmas variety with a relatively low index. In 3 of the F1 combinations, Ehtiyozh x To'maris (hp=0.4), Selekta 302 x Sochilmas (hp=0.4), Nena x Ehtiyozh (hp=0.5) characteristics were inherited in the case of incomplete dominance of the high-performance variety. The dominance condition was not observed in the hybrid combination of Ehtiyozh and Nena, depending on the parental forms (Table 1).

The heritability of the number of pods per plant trait in the first-generation hybrids was found to be inherited in a state of extreme dominance in all F1 combinations compared to the parental forms. The number of pods in the parent forms is 34.8-74.3, while the hybrids have 79.5-209.33 pods. In leguminous crops, the determining feature of seed productivity is the number and weight of grains per plant. This is because in all hybrid combinations, the characteristics are higher than the parental forms, and the character in the hybrids of the F1 generation can be seen as inherited in an extremely dominant position.

The 1000-grain weight trait is considered the main indicator of plant productivity and determines the technological quality of the seed. Samples with the largest seeds in parent forms are Sochilmas(154.0±0.01), and To'maris (160.7±0.01) varieties; these varieties are Sochilmas x Genetik-1 (hp=-1.9), Sochilmas x Selekta 302 (hp=-4.1), Genetic-1 x Sochilmas (hp=-1.7), Selekta 302 x In non-dispersive (hp=-2.8) combinations, the trait was inherited in a state of negative super-dominance. In the Ehtiyozh x Nena hybrid (hp=2.3), the inheritance of the trait in the state of positive dominance was observed. In the hybrid combinations of Tomaris x Ehtiyozh (hp=-0.4), and Nena x Ehtiyozh (hp=-0.8), it was inherited in the case of incomplete dominance of the low-performance variety depending on the parental forms. In the samples of the studied collection, the sign of plant height, respectively, the number of limbs in the plant have a strong positive relationship (r=0.95***), number of pods per plant, grain weight and the number of grains per plant as symbols (respectivelyr=0.52*; r=0.45*) is moderately positive to dependence if it has, the plant height of the oil and protein content of the grain to the height was found to be unrelated (Fig. 1). Key signs of productivity when analyzing the relationship between the number of pods in the plant and the number of grains (r=0.73***)and grain weight (r=0.92), and the symbol for grain weight per plant is the number of grains per plant (r=0.80) strongly positive between the sign correlation was observed. It was observed that the number of pods in the plant affected the number of grains. 1000 grain weight is the grain weight in the plant, which is r=0.43 ***, and plant branching with r=0.34*. Although moderately positively correlated, it showed weak low correlations with other traits. The amount of oil and protein in the plant is a sign of grain quality. The oil content of the grain is the main yield

characteristic with the number of pods per plant, grain weight, grain weight and protein content (respectively, r=0.43*; r=0.36*,r=0.42*; r=0.44*) showing an average positive correlation, it was found that other characteristics do not affect the change of oil content.



Explanation. * p<0.05, ** p<0.01, *** p<0.001

Figure 1. Correlation of indicators. 1- plant height; 2- the number of joints in the plant; 3 - branching; 4 – number of pods in one plant; 5 – grain weight in one plant; 6 – the number of grains in one plant; 7 – weight of 1000 grains; 8 – fatness; 9 – protein content

Discussion

The high soybean yield depends on its 1000 seed weight, number of pods, number of seeds per pod, number of limbs, etc. In addition, the selection of varieties suitable for soil-climatic conditions, resistance to various diseases and pests, and other similar factors depend on it (Leshchenko, 1987; Kurbanbaev *et al.*, 2008; Fayziyev *et al.*, 2020). Faisal et al. (2007) found that the number of pods in a plant has a positive correlation, in our experiments, a positive correlation was found between several economic characteristics of soybeans. The strong positive correlation between the number of pods per plant, the number of grains per plant, and the weight of the yielding traits is explained by the high efficiency of selection processes for soybean productivity.

In our recent studies, we conducted cross-breeding between local and foreign varieties using the soybean collections available at the Institute of Genetics and Experimental Plant Biology of the Academy of Sciences of Uzbekistan. We studied the productivity characteristics of the obtained first-generation hybrids. Local Sochilmas, Genetik-1, Ehtiozh, To'maris varieties, Selekta 302 belonging to the Russian selection, and Nena to the Kazakhstan selection were selected for breeding. The dominance coefficient for studied characters in F1 hybrids of soybean varieties was calculated according to the formula Griffing. Hybrids are usually characterized by the inheritance of several qualitative and quantitative parameters: seed color and shape, stem growth tendency, plant height,

number of joints on the main branch, stem branching, number of grains, number of pods, etc. It was found that the economic traits studied in F1 hybrids are mostly incompletely positive and highly dominant.

Conclusion

The experiment found that a high index was plant height, number of joints, plant branching, the number of pods per plant, grain weight per plant, number of grains per plant, and 1000 grain weight in the Ehtiyozh variety. As a result of the experiment, the height of the plant, the number of joints, the branching of the plant, the number of pods per plant, the weight of grains, the number of grains per plant, and the weight of 1000 grains are higher in the combination of Ehtiyozh x Tomaris from the Ehtiyozh variety and F1 hybrids were found to be an indicator. In the combinations of Ehtiyozh x Tomaris, Ehtiyozh x Nena, Selecta 302 x Sochilmas, and Tomaris x Ehtiyozh F1, it was found was mainly super-dominant in terms of valuable economic traits. However, a negative dominance was found for 1000 grain weight.

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