



Cluster Analysis of Physiological Traits in F1-F2 Plants and Varieties Belonging to *Phaseolus Vulgaris* L. Species

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Abstract: This article presents the results of cluster analysis of the physiological traits of F1-F2 plants obtained from original forms of *Phaseolus vulgaris* L. species and their hybridization. In our observations, we performed cluster analysis based on the parameters of physiological traits such as chlorophyll "a", "b", total chlorophyll, amount of carotenoids, transpiration rate, water storage properties of leaves, total water content of leaves. As a result, 4 cluster groups were revealed based on physiological traits, and the minimum and maximum Euclidean distance was found to be 0.1-12.0 units.

Keywords: *Phaseolus vulgaris*, common bean, hybrid, transpiration, cluster, total amount of water, pigment, chlorophyll, carotenoid.

Introduction

Legumes are an important tool for solving global challenges in agriculture and food supply, and their environmental and economic benefits contribute greatly to sustainability in this sector. The assimilation of free nitrogen from the air as a result of the activity of nodule bacteria in the roots of leguminous crops and, as a result, the enrichment of the soil with nitrogen increases the demand for planting crops such as beans, peas, mung beans, soybeans on larger areas.

In recent years, the increasing number of scientific and research works conducted on common bean plant from leguminous crops is said to be the development of science on the one hand, and on the other hand, it determines the high nutritional value of this plant.

Common bean (*Phaseolus vulgaris* L.) is the most important legume for human consumption worldwide. It is a rich and relatively inexpensive source of proteins and micronutrients, especially iron and zinc. Common bean is a crop with high Fe/Zn concentration that can help improve

malnutrition in developing countries, and biofortification is considered important to develop its new cultivars [7].

A series of research works on the physiological traits and genetics of the common bean plant and hybrids obtained on the basis of their hybridization serve to create protein-rich, economically effective varieties of this plant [1, 2, 8].

Common bean (*Phaseolus vulgaris* L.) is the most important food legume in the world. This staple food crop is considered an almost perfect food because it contains high protein and high amounts of fiber, complex carbohydrates and other daily needs such as vitamins (folic acid) and minerals (Cu, Ca, Fe, Mg, Mn, Zn) [5].

In genetic studies conducted, common bean samples sensitive to abiotic stresses and wild forms were crossed in interspecies hybridization. It was found that the resulting hybrids were resistant to cold and adapt to regions with a short growing season. At the same time, the in vitro method was also used in this research process, which served to successfully obtain some hybrid combinations [4].

In order to determine the physiological characteristics of the common bean plant in Brazilian conditions, Perola (sensitive to water stress) and BAT 477 (resistant to water stress) genotypes were grown under two different irrigation regimes, and under water deficit conditions, the yield was observed to decrease by 33% [3].

The object and the methods of the research.

If more than two populations were chosen to determine the physiological traits parameters of the original forms and F_1 - F_2 hybrids, then it was necessary to divide the genotypes into groups according to their proximity to each other. Therefore, it was required to determine the different levels of these varieties and hybrids in terms of physiological traits parameters and to combine the traits between them according to their mutual proximity, and to achieve this goal, the cluster analysis method was used.

In our research, 7 different physiological traits of the varieties and F_1 - F_2 hybrids of *Phaseolus vulgaris* L. species were analyzed to perform cluster analysis. The parameters of physiological traits of these varieties and F_1 - F_2 hybrids, such as chlorophyll "a", "b", total chlorophyll, the amount of carotenoids, transpiration rate, water retention properties of leaves, total water content of leaves were determined in the laboratory and statistical analysis was conducted.

In order to divide into cluster groups the original forms and F_1 - F_2 hybrids studied during our research, the Euclidean distance was used as a measure of genetic proximity in the Statgraphics computer program, and Ward's method was used as a unification method [6].

The results of the research

The minimum number of cluster groups combined in the analyzed original forms and F_1 - F_2 hybrids was 3, their maximum number was 7. In these varieties and F_1 - F_2 hybrids, the parameters of the traits such as transpiration rate, total water content of leaves, water storage properties of leaves, chlorophyll "a", "b", total chlorophyll, carotenoid concentration were determined and biostatistical analysis was carried out.

Four groups - clusters, which differ according to the set of traits studied above and retain their traits in genotypes and hybrid generations, were separated and analyzed (Table 1).

The first studied cluster group includes the varieties and hybrids Solnishko; F_1 Solnishko x Calipso krasnaya; F_1 Ravot x Calipso krasnaya; Belaya fasol; F_1 Calipso krasnaya x Solnishko; F_1 Ravot x Solnishko; F_1 Solnishko x Ravot, the sample combined to this cluster showed low parameters for all traits. In particular, the average rate of transpiration of samples in this studied group was 257.27 mg/g.s (Table 2).

Table-1 Separation into clusters according to physiological traits in original forms and F₁-F₂ hybrids

No. of cluster	No.of variety, F ₁ – F ₂	Varieties, F ₁ –F ₂ combined to clusters
I	1;9;14; 6; 10; 7; 8	Solnishko; F ₁ Solnishko x Calipso krasnaya; F ₁ Ravot x Calipso krasnaya; Belaya fasol; F ₁ Calipso krasnaya x Solnishko; F ₁ Ravot x Solnishko; F ₁ Solnishko x Ravot.
II	2;20; 5; 11; 16; 22;	Baby Lima; F ₂ Solnishko x Ravot; Vir; F ₁ Baby Lima x Calipso krasnaya; F ₁ Baby Lima x Vir; F ₂ Baby Lima x Calipso krasnaya.
III	13; 15; 18; 17; 19; 21	F ₁ Ravot x Baby Lima; F ₁ Solnishko x Baby Lima; F ₂ Solnishko x Baby Lima; F ₂ Ravot x Baby Lima; F ₂ Ravot x Solnishko; F ₂ Ravot x Calipso krasnaya.
IV	3; 4; 12	Calipso krasnaya; Ravot; F ₁ Calipso krasnaya x Baby Lima.

The second cluster group includes 6 varieties and hybrids, they are Baby Lima; F₂ Solnishko x Ravot; Vir; F₁ Baby Lima x Calipso krasnaya; F₁ Baby Lima x Vir; F₂ Baby Lima x Calipso krasnaya variety and hybrid plants, which mainly showed high values in terms of total water content, chlorophyll "b" traits. It was found that the total water content of the varieties and hybrids included in this cluster group is 84,45%, and the concentration of chlorophyll "b" is equal to 1,05 mg/g.

The third cluster group analyzed included only F₁-F₂ hybrids, and no varieties from the parent sources participated. The hybrids that participated in this composition are F₁ Ravot x Baby Lima; F₁ Solnishko x Baby Lima; F₂ Solnishko x Baby Lima; F₂ Ravot x Baby Lima; F₂ Ravot x Solnishko; F₂ Ravot x Calipso krasnaya F₁-F₂, common bean hybrids included in this cluster mainly consisted of samples with high transpiration rate (287.71 mg/g.s), water retention properties of leaves (40.57%) (2 -table).

Table-2 Physiological parameters in original forms and F₁-F₂ hybrids

No. of cluster	Transpiration rate (mg/g.s.)	Water retention capacity (%)	Total water amount (%)	chlorophyll "a" (mg/g)	chlorophyll "b" (mg/g)	Total chlorophyll (mg/g)	carotenoids (mg/g)
I	257,27	34,92	83,69	1,58	0,82	2,40	0,50
II	256,41	37,85	84,45	2,11	1,05	3,13	0,49
III	287,71	40,57	77,75	1,86	1,02	2,89	0,45
IV	197,40	23,68	84,45	2,34	0,96	3,31	0,78

The varieties and F₁ hybrids included in the fourth cluster group Calipso krasnaya; Ravot; F₁ Calipso krasnaya x Baby Lima combination was found to have the highest physiological parameters. In the sample included in this cluster, the total water content was 84.45%, the concentration of chlorophyll "a" was 2,34 mg/g, the total chlorophyll was 3,31 mg/g, and the concentration of carotenoids was 0,78 mg/g.

As a result, Belaya fasol variety included in the first group of the cluster analysis was found to have the lowest indicators for the rate of transpiration (165.9 mg/g.h) and chlorophyll "b" (0,57 mg/g), and Baby Lima variety, which included in the second cluster group showed transpiration rate 247.0 mg/g.s. chlorophyll "b" 0,96 mg/g, while the water retention property in the Ravot

leaves was 22.1%, carotenoid concentration was 0,84 mg/g and it is superior to other varieties in terms of these physiological traits.

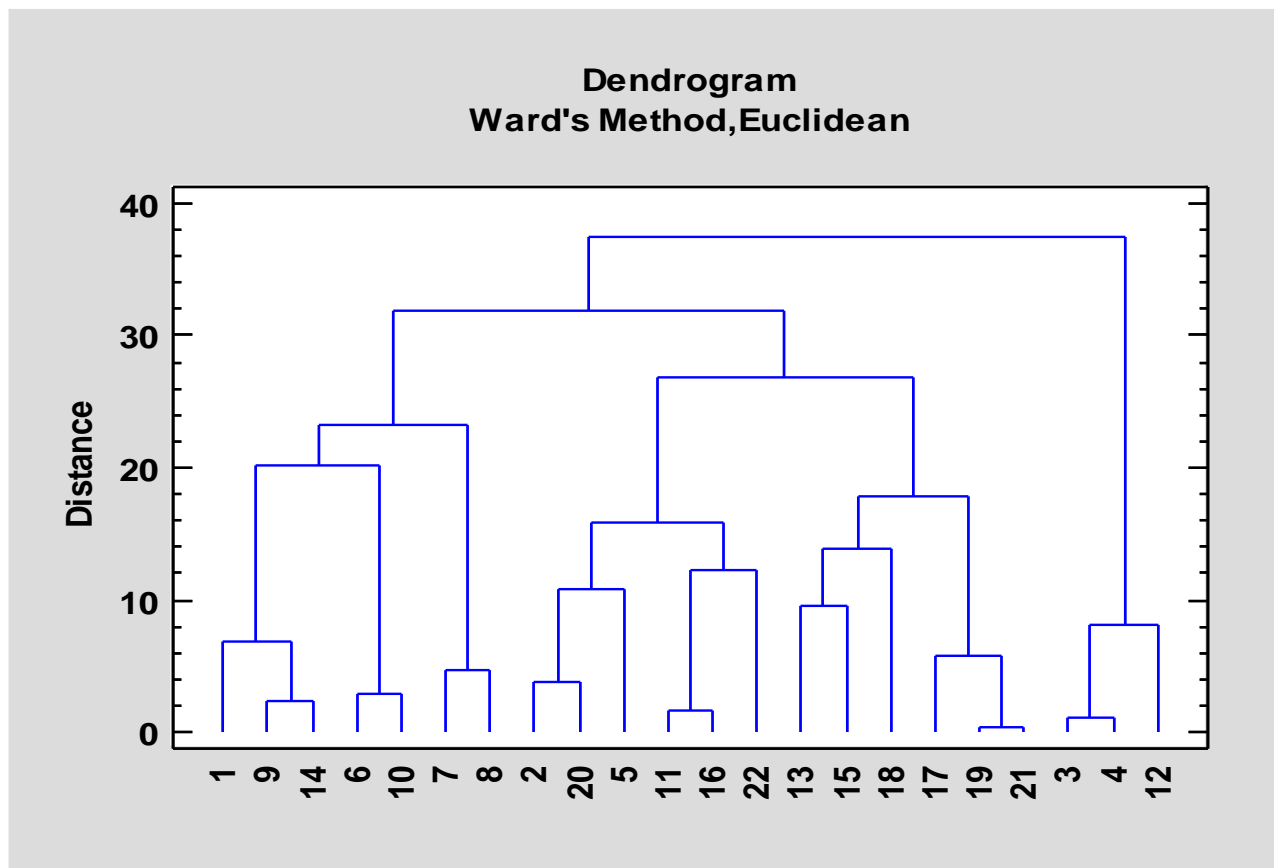


Figure-1. Dendrogram of separation into clusters by physiological traits in original forms and F₁-F₂ hybrids.

Euclidean distance was found to be 0.1-12.0 units as a measure of genetic proximity in the varieties and hybrids included in all cluster groups. But when analyzing the distance by groups, it was found that the distance difference in the first cluster group was 5.0 units, that is, it was 2.0-7.0 units (Figure 1).

In the remaining groups, it was observed that there was a distance of less than 1.0, in the second cluster it was 0.8-12.0, in the third group it was 0.1-9.0, in the fourth cluster group the distance was found to be between 0.2-8.1.

Conclusion

From our researches, it became known that the separation of studied varieties and hybrids into 4 cluster groups according to their physiological traits and characteristics was shown to be moderate. The Euclidean distance for all groups was found to be between 0.1 and 12.0 units. The minimum number of varieties and hybrids in physiological traits clusters was 3, and the maximum number was 7.

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