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in

Ricciardi L. (ed.), Myrta A. (ed.), De Castro F. (ed.).
Italo-Albanian cooperation for the enhancement of plant biodiversity

Bari : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 47

2001
pages 117-126

Use of phenotypic distances for the effective genetic variation of some bean populations

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Summary

The phenotypic distances are widely used for plant breeding to decide appropriate schemes of reproduction and to discriminate genetic resources. Eleven bean populations, collected in North Albania, have been studied. They were characterised and estimated by a large number of bio-morphological indicators of the plants and seeds relevant to the bean plant and in accordance with the list of indicators determined by IBPGR. Data were processed according to the method of in-between-groups linkage of the cluster analysis. The grouping was decided by virtue of the Euclidian distance and the Pearson's correlation coefficient. When populations clustered in separate groups they had an extreme phenotypic similarity and therefore they were considered as homologous; if comparing groups to one another there was an extreme dissimilarity they were considered as heterogeneous.

The processed data indicated that the populations were clustered in different groups such as: E Kuqe e Komanit was clustered in the first group; E Kupe e Gjegjanit, Tetovcë (Merturi), Laramane e zezë, Qorre e zezë, Rrilë e Berishës and the E Bardha e Malësisë was included in the second group; the Ehershmja e Bjeshkés was in the third group and the Plloçakja e bardhë was in the fourth group.

Since the groups were not highly dissimilar for the studied traits, separate accessions for each group may be overviewed and generalizations may be therefore made even for other accessions based on the correlation coefficients by way of value vectors for all the characteristics taken together and for each separate accession.

Information is given on the most appropriate cross-pollination schemes to adopt for the examined genetic material.

Key words: phenotypic distances, Euclidian distances, genetic similarity.

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1. Introduction

The morphological features are widely used for taxonomy purposes (Sokal and Sneath, 1963) and for group classifications of accessions. Such classifications will certainly lead to the formulation of appropriate cross-pollinated schemes by means of cultivars for the hybridisation of juvenile desired plant forms of high productivity and other desired characteristics.

In order to classify the cultivars in groups, it's proper to fix the limit of similarity (or dissimilarity), called: difference function, for the accessions to be grouped together, and determined according to the genetic effects.

Due to the action of some factors, germplasm is under the pressure of limiting the genetic potential on the one hand, and increasing the genetic variability on the other hand. For that reason, the estimation and the effective use of germplasm for genetic improvement constitutes one of the main priorities for the work in that area.

2. Material and methods

Eleven bean populations, collected in North Albania, precisely in Pukë, Kukës, Has, Tropojë and Shkodër were under study. This zone represents a typical mountainous territory, covered with forests and pastures that occupy 80-90% of the territory. The selected bean populations are: E Kuqe e Komanit, Kuqaloshe, Kapse e Gjegjanit, Tetovcë e Merturit, Rrilë e Toplanës, E Hershme e Bjeshkëve, Pllocake e bardhë, Laramane e zezë, Qorre e zezë, Rrilë e Berishës and e Bardha e Malësisë. The above populations were planted in the village Mërtur of Puka so as to characterize and estimate some bio-morphological indicators of plants and seeds in conformity with the list of indicators as determined by IBPGR for the bean plant.

The estimated indicators were the following: stem length (cm); stem diameter (mm); number of nodes per plant; flowering time (days); number of flowers per plant; number of flowers per inflorescence; length of pod; width of pod; days of ripening; number of pods per plant; number of seeds per pod; number of seeds per plant; weight of 1,000 seeds (g); seed length (mm); seed width (mm); seed thickness (mm); length to width ratio (seed); thickness to width ratio (seed) and yield per plant (g).

A random block design, composed by 2 m^2 plots with three replicates, was adopted. Observations and measurements were made for 10 plants per replicates.

The samples were collected in 18 villages, that belonged to 5 districts in

North Albania having different heights above the sea level, precisely: 25% of samples were collected in villages that were 200-300 m high above the sea level; 15% were collected in villages that were 300-400 m high above the sea level ; 40% were collected in villages that were 400-500 m high above the sea level (hence, the majority of the samples were collected at this height); 10% of samples were collected in villages of 500-600 m high above the sea level and the rest 10% of samples were collected in the villages stretching 700-800 m high above the sea level.

In order to avoid variation of values, caused by errors in measuring, the mean value of three years was used for each characteristic. The method of in-between-groups linkage of cluster analysis was used to process the data. The groupings were determined by:

a. Euclidian distances,

$$ED_{ij} \quad \sum_{r\ 1}^{P} (X_{ir} \quad X_{jr})^2 \quad ^{1/2}$$

in which:

Ed_{ij} Euclidian distance between populations (vectors) I and J.

X_{ir} and X_{jr} average values of feature r (coordinates of place r), estimated respectively for populations (vectors) I and J.

b. Pearson's correlation coefficient,

$$R_{ij} \quad \frac{\sum_{i\ 1}^{r} (X_{ir} \quad \overline{X}_i)(X_{jr} \quad \overline{X}_j)}{(\sum_{r\ 1}^{p} (X_{ir} \quad \overline{X}_i)^2 \sum_{r\ 1}^{p} (X_{jr} \quad \overline{X}_j)^{1/2}}$$

in which:

R_{ij} Pearson correlation between populations I and J.

X_{ir} and X_{jr} average values of feature r (coordinates of place r), estimated respectively for populations (vectors) I and J.

$\overline{X}_i$ and $\overline{X}_j$ relevant averages of populations I and J.

The results of data were processed through the programme SPSS at the Centre of Informatics of Agricultural University of Tirana.

This function is more frequently used as compared to the others (Goodman, 1969; Jacquard, 1970) and the distance according to this function is easily calculated, but is disadvantageous, as it doesn't take into

account the interactions among traits. It should be stressed that no procedure is absolutely good in any condition (De Pace et al., 1987).

Since the selection of variables affects the results of this analysis (Anderberg, 1973), the 22 above traits were used as variables. The linear model of cluster analysis procedure is determined by the scheme matrix (Camussi, 1986) of type 22x22 in our case.

By means of the above method the populations were clustered into groups, where each algorithm began from a starting point and through a continuation the shift from one point to another in the multi-dimensional space gave an improved value (standard) of the function, until an optimal value was found.

3. Results and discussion

The data processing showed that the populations were clustered in several groups as given in Tab. 1.

Tab. 1. Population groupings

Populations	Groups
E Kuqe e Komanit	1
Kuqaloshe	2
Kapse e Gjegjanit	2
Tetovcë e Mërturit	2
Rrilë e Toplanës	1
E Hershme e Bjeshkëve	3
Pllocake e bardhë	4
Laramane e zezë	2
Qorre e zezë	2
Rrilë e Berishës	2
E Bardha e Malësisë	2

By using the averages for each trait in the three years, the variation caused by the years was reduced to a certain extent, offering therefore opportunities for accurate population groupings.

As show in Tab. 1, with regard to the number of individuals (populations) in groups, there is an evident vacillation: from the accession (7) of group four into six (2, 3, 4, 8, 9, 10, 11) accessions of group 2. As a result of different number of cultivars clustered in each group, the frequency of population groupings differs: for group 1-18.181%, for group 2 -54.545%, for group 3-18.181% and for group 4- 0.093%. The composition of certain groups reconfirms the fact that the geographical distances often do not fit the phenotypic and genetypical distances, although the latter are expressed to some extent by the phenotype of plants.

When populations were clustered in separate groups they had an extreme phenotypic similarity and for that reason they were considered as homologous; when comparing groups to one another there was an extreme dissimilarity and therefore they were considered as heterogeneous.

Since within groups there was a high similarity for the studied characteristics, we could analyse separate characteristics for each group and make generalisations even for other accessions (populations). To this end, as shown in Tab. 2, the correlation coefficients were calculated through vectors of values for all the characteristics taken together and for separate accessions.

Tab. 2. Correlation coefficients among vectors of phenotypic values for the studied traits

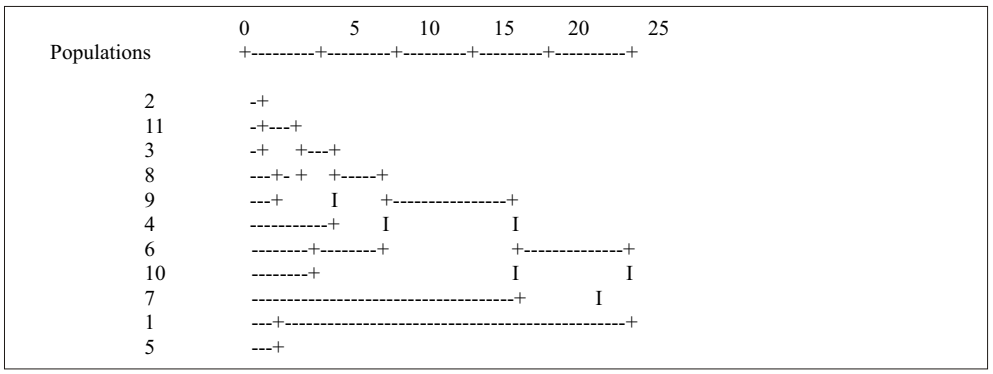
Pop.	Correlation coefficients										
	1	2	3	4	5	6	7	8	9	10	11
1											
2	0.766										
3	0.774	0.991									
4	0.684	0.956	0.946								
5	0.980	0.753	0.770	0.678							
6	0.872	0.896	0.889	0.903	0.881						
7	0.641	0.846	0.842	0.927	0.700	0.902					
8	0.831	0.979	0.981	0.949	0.801	0.922	0.824				
9	0.806	0.947	0.962	0.948	0.781	0.906	0.829	0.985			
10	0.859	0.953	0.942	0.953	0.832	0.965	0.868	0.980	0.963		
11	0.800	0.994	0.989	0.958	0.774	0.910	0.835	0.994	0.970	0.972	

As the Tab. 2 clearly indicates, these correlations constituted the basis both to know the level of affinity and the appropriate crossing schemes among populations classified in different groups.

Therefore, the appropriate crossing schemes may be: 1 x 4, 1 x 7, 2 x 5, 3 x 5, 4 x 5, 5 x 7, 5 x 9, 5 x 11 because the correlation values of linkage vectors were respectively: 0.684; 0.641; 0.753; 0.770; 0.678; 0.700; 0.781 and 0.774. On the other hand, crossing should not be made based on the schemes: 2 x 3; 2 x 11; 3 x 11; 6 x 10; 8 x 11; 9 x 11 and 10 x 11, since the correlation values were very high (which indicates that they were not dissimilar: 0.989; 0.965; 0.994; 0.970; 0.972). The populations used for crossing belonged to different groups, whereas the populations, which should not be crossed with each other, were included in the same group. This was confirmed also by the values of correlations through vectors of value. Therefore, in order to design effective crossing schemes so as to generate genetic variations among the offspring, parents must differ from each other or be included in different groups. Moreover, the design of crossing schemes should be based on the correlation values of vectors for all the characteristics taken together.

In order to formulate a clear idea for the combination of parental components, the researchers should base themselves on the dendogram of population links with each other, as given below:

Fig. 1 Dendogram of linkage among populations.



Even the above dendogram helps for the selection according to the Euclidian distance. The most appropriate schemes for crossing the studied populations were 1 x 2; 1 x 11; 2 x 5; etc.

Dendogram gives a detailed picture of the link among separate populations by offering opportunities to the plant breeders to make a complete synthesis on the linkage level for all the populations taken for study.

4. Conclusions

The study shows that the formulation of appropriate crossing schemes by way of different accessions based on phenotypic distances, should be concentrated on:

Clustering of accessions in groups;

Correlations among vectors of values for all the studied traits;

Dendogram that expresses the link of accessions with one another.

We notice that the conclusions drawn, while defining the grouping according either to Euclidian distance or correlation coefficients, are the same, which increases the security of group classification.

As stated above, the most appropriate crossing schemes among 11 studied populations are: E Kuqe e Komanit x Kuqaloshe; E Kuqe e Komanit x Tetovcë e Mërturit ; E Kuqe e Komanit x Pllocake e bardhë ; E Kuqe e Komanit x E Bardha e Malësisë ; Kuqaloshe (Reddish) x Rrilë e Toplanes; Kapse e Gjegjanit x Rrilë e Toplanës; Tetovcë e Mërturit x Rrilë e Toplanes; Rrilë e Toplanës x Pllocake e bardhë; Rrilë e Toplanês x Qorre e zezë and Rrilë e Toplanës x E Bardha e Malësise.

Below are reported the main characteristics of studied populations.

E kuqe e Komanit

Plant characteristics: It is bushy, 25-30cm high. Flowering time lasts 37 days. It has 4-5 inflorescences and every inflorescence has 4-5 white flowers. It's a little threadlike and has 11 cylindrical pods. Pods are 12-15 cm long and easily bent. Each pod has 5-6 seeds. The vegetation period lasts 88 days. It resists drought, diseases and pests. It produces up to 30 q/ha.

Seed characteristics: The seed has a flat surface, is its colour is dark creamy. It is 15 mm long, 6 mm wide, 6 mm thick and the 1000 seed weight is 38 g.

Tetovcë e Mërturit

Plant characteristics: The plant belongs to the climbing type and is up to 2.5m. Flowering time lasts 35 days. It has 11-13 inflorescences and every inflorescence has 6-7 white flowers. The plant has 14-19 padlock pods (15 cm long) and each pod has 6-7 seeds. It is threadlike and slightly bent. The vegetation period lasts 127-130 days. It demands water and slightly resists diseases and pests. It produces up to 35 q/ha.

Seed characteristics: The seed is kidney-shaped and white. It is 18 mm long, 10.6 mm wide, 4 mm thick and the 1,000 seed weight is 68 g.

E Hershmja e Bjeshkës

Plant characteristics: The average height of the plant is 103 cm. It has 8-9 nodes. Flowering time lasts 38 days. It has 14-15 inflorescences and every inflorescence has 4-5 white flowers. It has 15-17 seed per pods and each pod has 5 seeds. It's sward-like, 10 cm long, slightly threadlike, the beak bent downward. The vegetation period lasts 95 days. It resists drought and is very resistant to diseases and pests. It produces up to 35 q/ha.

Seed characteristics: The seed is round and white. It is 12.5 mm long, 6.7 mm wide, 7 mm thick and the 1,000 seed weight is 46 g.

Rrila e Berishës

Plant characteristics: The average height of the plant is up to 118 cm. Flowering time lasts 37-38 days. It has 12 inflorescences and each of them has three white flowers. The plant has 15 padlock pods being 11cm long and each pod has 5-6 seeds. It's much threadlike, slightly bent and the beak is downward. Vegetation period lasts 98 days. It is resistant to drought and very resistant towards diseases and pests. It produces up to 30 q/ha.

Seed characteristics: The seed is kidney-like and white. It is 15 mm long, 8 mm wide, 5.3 mm thick and the 1,000 seed weight is 46.3 g.

Rrila e Toplanës

Plant characteristics: The plant's gowth is limited; it grows 28-30 cm high. Flowering time lasts 35 days. It has 4-5 inflorescences and each of them has 5 white flowers. The plant has 15 sward-like pods being 10-11cm long and each pod has 4 seeds. It's slightly threadlike, slightly bent and the beak is downward. Vegetation period lasts 86 days. It is resistant to drought and gets easily infected by diseases and pests. It produces up to 23 q/ha.

Seed characteristics: The seed is kidney-like and white. It is 15.1 mm long, 6.3 mm wide, 6 mm thick and the 1,000 seed weight is 51 g.

Qorre e Zezë

Plant characteristics: The plant belongs to the climbing type and grows 150 cm high. Flowering time lasts 58 days. It has 11 inflorescences and each of them has 3-4 white flowers. The plant has 11-12 pear-like pods which are 11-12 cm long and each pod has 5-6 seeds. It is threadlike, slightly bent. Vegetation period lasts 120-123 days. It is moderately resistant to diseases and pests. It produces up to 20 q/ha.

Seed characteristics: The seed is kidney-like. Its colour is dark-brown. The seed is 11.6 mm long, 6mm wide, 5 mm thick. and the 1,000 seed weight is 28 g.

Plloçakja e Bardhë

Plant characteristics: The plant belongs to the climbing type and is characterised by solid growth up to 2.5 cm high. Flowering time lasts 34-35 days. It has 10-11 inflorescences and each of them has 15-18 white flowers. The plant has 13-17 pear-like pods which are 12cm long and slightly threadlike. It doesn't shell easily and each pod has 3-4 seeds. Vegetation period lasts 118 days. It gets easily infected by diseases and pests. It produces up to 40 q/ha.

Seed characteristics: The seed is kidney-like and white. It is 22.3 mm long, 11 mm wide, 10 mm thick and the 1,000 seed weight is 151.3 g.

Laramane e Zezë

Plant characteristics: The plant climbs to the height 145 cm. Flowering time lasts 40 days. It has 18-21 inflorescences and each of them has 6-7 white flowers. The plant has 15-17 pear-like pods being 11 cm long and each pod has 5-6 seeds. It's slightly threadlike and slightly bent. Vegetation period lasts 120 days. It is very resistant to diseases and pests. It produces up to 24 q/ha.

Seed characteristics: The seed is kidney-like. It's creamy with some black nuances. The seed is 12 mm long, 6.6 mm wide, 5 mm thick and the 1,000 seed weight is 28.3 g.

Kapse e Gjegjanit

Plant characteristics: The plant climbs up to 160-166 cm high. Flowering time lasts 50 days. It has 19-22 inflorescences and each of them has 4-5 white flowers. The plant has 12-17 elliptic pods, which are 12-13 cm long, and each pod has 3-4 seeds. The pod has a straight bent beak. Vegetation period lasts 120-125 days. It is very resistant to diseases and pests. It produces up to 29 q/ha.

Seed characteristics: The seed is kidney-like. Its colour is light creamy. The seed is 10.3 mm long, 7.6 mm wide, 5.6 mm thick and the 1,000 seed weight is 29.6 g.

Kuqaloshe

Plant characteristics: The plant climbs up to 1.9 m high. Flowering time lasts 12-15 days. It has 12-15 inflorescences and each of them has 3-4 white flowers. The plant has 16 padlock pods being 11-13 cm long and each pod has 5-6 seeds. It's slightly threadlike and slightly bent. It doesn't shell easily. Vegetation period lasts 124-126 days. It gets easily infected by diseases and pests. It produces up to 25 q/ha.

Seed characteristics: Form of the seed is irregular. It's creamy to yellow. The seed is 12.6 mm long, 7.6 mm wide, 6 mm thick and the 1,000 seed weight is 31-34 g.

E Bardha e Malësisë

Plant characteristics: The plant climbs up to 1.9 m high. Flowering time lasts 64 days. It has 13-16 inflorescences and each of them has 4 white flowers. The plant has 16-17 sword-like pods which are 15 cm long and each pod has 5-6 seeds. It's more or less threadlike, slightly bent with the beak oriented downward. Vegetation period lasts 140 days. It is easily infected by diseases and pests. It produces up to 36 q/ha.

Seed characteristics: The seed is kidney-like and white. It is 11 mm long, 7 mm wide, 5 mm thick and the 1,000 seed weight is 31.3 g.

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