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Research paper

Evaluation of agro-morphological traits of Chitti bean lines using multivariate analyses

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Abstract
Improving knowledge on the relationships between agro-morphological traits in Chitti bean (*Phaseolus vulgaris* L.) will contribute to identifying key traits affecting grain yield for use in bean breeding programs. A field experiment was conducted using an augmented design consisting of 116 breeding lines and three checks (Sadri, Kousha, Khomein local). Statistical analysis showed that grain yield and seeds per plant had the largest variations. Regression analysis showed that days to emergence of the first trifoliate leaf (V_3), seeds per pod, and plant height, explained more than 39 percent of the variation in grain yield. Path analysis indicated a high negative direct effect of V_3 and a positive direct effect of seeds per pod on grain yield. Cluster analysis helped to classify all genotypes into four distinct groups. From the genotypes studied, 38 superior genotypes were selected, which can be used in the breeding programs of Chitti bean Also, number of days to emergence of the first trifoliate leaf and the number of seeds per pod were identified as traits useful to consider in bean breeding programs aiming at improving the grain yield of Chitti beans.

Keywords: Common bean; Multivariate analysis; Pods per plant; Seeds per pod; Yield components

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Abbreviation
V_1: Days to emergence; V_2: Days to the emergence of the primary leaves; V_3: Days to the emergence of the first trifoliate leaf; V_4: Days to the emergence of the third trifoliate leaf; R_5: Days to floral initaiation; R_6: Days to flowering; R_7: Days to pod formation; R_8: Days to seed filling; R_9: Days to maturity

Introduction

Identifying useful bean characteristics is important in germplasm conservation and genetic improvement in breeding programs (Chiorato *et al.* 2007). Using some statistical methods, we can obtain the information necessary for the indirect selection of traits to improve grain yield (Farshadfar 1997). Chiorato *et al.* (2005) studied the genetic variation of various traits in beans to be used in breeding programs. Blair *et al.* (2009) examined 604 genotypes of CIAT germplasm for several traits, including seed size, and concluded that the common bean has a very good demographic structure that can be used in the cross between genotypes to create genetic diversity and as a basis for other studies. In a study on the qualitative and quantitative traits of bean germplasm in Serbia, multivariate statistical methods were used to investigate the genetic diversity among genotypes for agronomic traits. Also, effective traits on seed yield were identified as plant height, number of pods per plant, number of seeds per plant, percent protein in grain, and form of grain (Vasi *et al.* 2008). Sanjiev Deshpand *et al.* (2010) evaluated agronomic and morphological traits such as yield, marketing quality of the grain, and early maturity in 225 bean genotypes using an augmented experimental design. Appropriate genotypes were identified as parents for breeding or for direct selection to release as cultivars. In another study, there was a high variation in yield, the number of pods per plant, 100 seed weight, and seed number per pod among bean genotypes while the length of growth period of genotypes was not significantly different (Awan *et al.* 2014). Keshavarznia *et al.* (2013) evaluated morphological and agronomical characteristics of 89 bean genotypes and the relationships between different traits were analyzed. The results showed that the highest amount of phenotypic variation was related to plant height and yield. Stepwise regression analysis showed that number of pods per plant, 100 seed weight, and seed number per pod had the greatest effects on grain yield. Azizi *et al.* (2001) studied genetic variation in 121 genotypes of white, red, and Chitti beans grown in Isfahan, Iran. Large genotypic and phenotypic variation was observed and among the tested traits, plant yield, number of pods per plant, 100 seed weight, and number of branches showed a greater coefficient of variation. The number of days to maturity was the least variable trait.

At present, the main goals of common bean improvement research in Iran are the identification, selection, and development of high yielding and marketable varieties with appropriate plant types (Ghanbari 2015). Market values for Chitti beans include large seeds, the background color, light cream with red to purple veins, and round grain form. For white beans, this includes grain with a shiny white background and 100 seed weight of about 30 grams. For red beans, depending on the area of consumption, this includes capsules with light seed color or cultivars with a 100 seeds weight of about 30 grams in bright or dark color. Considering the importance of identifying useful traits of beans in the selection and release of new varieties, the present study was aimed to determine agro-morphological traits affecting yield among international lines of Chitti bean for utilization in the breeding programs.

Material and Methods

A field experiment was conducted in 2014 to evaluate agro-morphological traits, growth and development characteristics, yield, and yield components of 116 Chitti bean (*Phaseolus vulgaris* L.) lines using an augmented design at Seed and Plant Improvement Institute (SPII), Karaj, Iran. Some of these lines resulted from crosses between Iranian genotypes with the genotypes either developed by International Center for Tropical Agriculture (CIAT) or cultivars collected from other leading bean cultivating countries.

Before planting, 70 kg ha^{-1} of phosphorus (P) in the form of ammonium phosphate and 30 kg ha^{-1} of nitrogen (N) in the form of urea were applied to the field. At the beginning of flowering, 12 kg ha^{-1} of N in the form of urea was distributed before irrigation in the field. The lines were sown in six blocks and each block consisted of 20 lines as well as three checks (Sadri, Koosha, Khomein local). The lines were sown in two-meter rows with a row to row spacing of 60 cm and a plant to plant spacing of 5 cm. The drip irrigation system was used to assure adequate soil moisture for crop growth, development, and yield. The studied agro-morphological traits were plant height, number of branches, plant type, phenological stages in vegetative and reproductive phases, yield, yield components, and marketing traits of grain.

Vegetative and reproductive growth stages: The number of days from planting until 50% of the plants of each plot show the signs of the emergence of each stage, were recorded for each genotype. The vegetative phase consisted of days to emergence (V_1), days to emergence of the primary leaves (V_2), days to emergence of the first trifoliate leaf (V_3), and days to emergence of the third trifoliate leaf (V_4). The reproductive phase included days to floral initiation (R_5), days to flowering (R_6), days to pod formation (R_7), days to seed filling (R_8), and days to seed maturity (R_9).

Plant height and number of branches: At the end of the pod filling period (growth stage R_8), five plants were randomly selected from each plot and their plant height was recorded in cm from the ground and the number of branches was also counted.

Yield and yield components: At harvest time, the number of pods per plant was determined from the count of pods in the five plants per genotype, and the number of seeds per pod was determined from the count of seeds in 10 pods. To determine the grain weight, 100 seed samples were weighed from each treatment and their mean weight was recorded as 100 seed weight. Plant grain weight, seed weight per plant, and number of seeds per plant were also determined. The length of the longest pod in each treatment was obtained in cm using the average value of 10 pods of five plants.

Plant type and marketing value of grain: To better interpret the results and help in selecting the superior lines, two qualitative traits of plant type and grain marketing were evaluated. There are four plant types in beans, three of which are common in Iran. Type 1 is the determinate growth with the upright stand. Type 2 is the indeterminate growth with the upright stand, and type 3 is the indeterminate growth type with prostrate growth habit. The plant type was determined during the seed filling period.

The marketing value of the grain was graded from 4 (excellent) to 1 (poor) based on the apparent quality of the grain (grain shape, grain size, grain field color, grain veins, grain brightness). The highest market value was number 4 and the lowest number was 1. Most of the lines were graded as marketable 3 (good).

Data analysis: To determine the homogeneity of the land, the analysis of variance was performed on the checks. The insignificance of the difference between blocks was considered as the uniformity of the test. Calculation of the correlation coefficients between traits, stepwise regression analysis, path analysis, and cluster analysis by Unweighted Pair Group Method with Arithmetic Mean (UPGMA) method was performed. We used SAS 9.1 and SPSS 16 software to analyze the data.

Results and Discussion

To best manage the hybridization projects, parents should be selected according to the desired traits at a suitable genetic distance from each other. The greater the distance between the parents, the greater the chance of obtaining a heterotic F_1 (Arunachalam 1981). The results of this study, considering the use of diverse germplasm of Chitti beans, as well as the evaluation of important agronomic traits, will be a good guide for bean breeders to select parents in breeding projects.

The results of the analysis of variance for the checks showed that there was no significant difference between the experimental blocks in terms of traits and there was no need to correct the means in blocks. The statistics including mean, maximum, minimum, standard deviation, and phenotypic coefficient of variation for the studied traits (Table 1) showed that there was a large variation among the genotypes and this diversity could be considered as an appropriate genetic reserve, which can help breeders in improving Chitti beans. The highest coefficient of variation was related to plant yield and the number of seeds per plant. The statistical parameters of the studied traits are presented in Table 1.

Correlation coefficients: Seven traits (number of days to emergence of primary leaves, number of days to the appearance of the first trifoliate leaf, number of days to emergence of the third trifoliate leaf, and plant type with negative coefficients and number of branches, number of pods per plant, and seed number per pod with positive coefficients) had significant correlation with grain yield (Table 2).

Regression analysis: Stepwise regression analysis results are presented in Table 3. Three attributes (days to emergence of the first trifoliate leaf, number of seeds per pod, plant height) in total justified more than 39% of the variation in grain yield. Table 4 shows the degree of multicollinearity among the independent variables. In statistical terms, a multiple regression model where there is high multicollinearity will make it more difficult to estimate the relationship between each of the independent variables and the dependent variable. Using variance inflation factor (VIF) or tolerance helps to identify the severity of any multicollinearity issues so that the model can be adjusted. When VIF is higher than 10 or tolerance is lower than 0.1, there is significant multicollinearity that needs to be corrected. According to the results of the present study, none of the studied traits had a tolerance higher than 10.

The role of bean traits in yield changes has been investigated using multiple regression analysis and different results have been reported. In Safapour *et al.* (2009), regression analysis showed that the number of days to pod filling, the number of days to seed maturity, the length of the longest pod, the number of seeds per plant, the weight of 100 seeds, and the length of the main-root had the highest effects on grain yield. In another study, the relationships between morphological traits were investigated in 121 genotypes of white, red, and Chitti beans. Based on the stepwise regression results, this study found that the number of pods per branch was the most important component in the variation of yield, and the number of pods per main stem, 100

Table 1. Statistics of the evaluated agromorphological traits in Chitti bean lines.

Trait	Min. and Max.	Mean	Std. Error	Variance	Phenotypic CV (%)
V_2	11-19	16.1	0.28	9.59	19.24
V_3	16-22	19.3	0.82	2.80	8.67
V_4	24-30	27.4	0.84	2.80	6.10
R_5	33-55	40.9	4.41	24.06	11.99
R_6	46-87	53.2	5.79	36.56	11.36
R_7	50-93	60.2	6.79	56.20	12.44
R_8	82-114	94.7	7.05	45.01	7.08
R_9	92-126	103.3	6.14	35.33	5.75
Plant height (cm)	30-118	54.4	17.38	335.09	33.59
Branches per plant	3-9.3	5.6	1.42	1.85	24.20
Pods per plant	7-34.3	15.7	6.10	23.94	31.14
Pod length (cm)	9.2-18.1	11.8	1.43	1.93	11.76
Seeds per pod	2.7-6.4	4.5	0.79	0.59	17.05
Seeds per plant	29-161	66.3	26.68	485.62	34.20
100 seed weight (g)	32.6-66.2	45.2	6.55	35.44	13.14
Grain yield per plant (g)	7.7-45.5	19.9	6.99	63.74	40.10

V_2: Days to the emergence of primary leaves; V_3: Days to the emergence of the first trifoliate leaf; V_4: Days to the emergence of the third trifoliate leaf; R_5: Days to floral initiation; R_6: Days to flowering; R_7: Days to pod setting; R_8: Days to pod filling; R_9: Days to maturity; CV: Coefficient of variation

Table 2. Correlation coefficients of yield attributed traits with grain yield per plant in Chitti bean lines (only significant correlations are shown).

Trait	V_2	V_3	V_4	Branches per plant	Pods per plant	Seeds per pod	Seeds per plant
Grain yield per plant	-0.528 **	-0.570 **	-0.523 **	0.231 *	0.208 *	0.215 **	0.174 *

* and ** are significant at the 5% and 1% levels of probability, respectively.

V_2: Days to the emergence of primary leaves; V_3: Days to the emergence of the first trifoliate leaf; V_4: Days to the emergence of the third trifoliate leaf.

Table 3. Stepwise regression analysis of traits in Chitti bean lines.

Model	R	R^2	R^2 *adj*	Standard error of the estimate	F
V_3	0.570	0.325	0.319	6.5876	56.329**
Seeds per pod	0.613	0.375	0.365	6.3646	34.843**
Plant height	0.638	0.407	0.391	6.2285	26.296**

**significant at the 1% level of probability.

V_3: Days to the emergence of the first trifoliate leaf.

Table 4. Collinearity statistics based on stepwise regression model concerning the Chitti bean lines under investigation.

Trait	Collinearity Statistics	
	Tolerance	VIF
V_2	0.116	8.611
V_4	0.212	4.717
R_5	0.877	1.140
R_6	0.957	1.045
R_7	0.880	1.136
R_8	0.896	1.116
R_9	0.867	1.153
Branches per plant	0.966	1.091
Pods per plant	0.916	1.071
Pod length	0.772	1.296
Seeds per plant	0.934	1.185
100 seed weight	0.844	1.052

Final model: Constant, V_3, Seeds per pod, Plant height.
V_2: Days to the emergence of primary leaves; V_3: Days to the emergence of the first trifoliate leaf; V_4: Days to the emergence of the third trifoliate leaf; R_5: Days to floral initiation; R_6: Days to flowering; R_7: Days to pod setting; R_8: Days to pod filling; R_9: Days to maturity.

seed weight, and the number of seeds per pod was found to be in the next ranks (Azizi *et al.* 2001).

Path analysis: The results of path analysis (Table 5) showed the significant and negative direct effect (-0.428) of the number of days to emergence of the first trifoliate leaf (V_3) on grain yield per plant. After V_3, the number of seeds per pod, and plant height had significant direct effects on grain yield. Therefore, these traits can be useful for breeding programs.

The indirect positive and significant effect of the days to emergence of the first trifoliate leaf on grain yield was through the number of branches and number of pods per plant (Table 5). In other words, with the improvement of the V_3 trait, the branches and pods per plant can be increased and eventually added to the plant's grain yield. As can be seen in Table 5, the indirect effect of the number of branches on grain yield through the number of pods per plant was also significant. Therefore, by increasing the number of branches, the number of pods per plant and, consequently, the yield of the plant could increase. In contrast, the indirect effects of the number of branches and number of pods per plant via plant growth stages, V_2, V_3, and V_4 negatively affected the grain yield per plant. Therefore, Chitti bean breeding should focus on reducing the length of these vegetative stages.

In the study of 250 samples from the red bean collection of the Iranian National Plant Gene Bank, it was observed that 100 seed weight, number of pods per plant, and number of seeds per pod could explain 97.7% of the variation in grain yield and these traits had the highest direct effect on grain yield (Rahnamaie Tak *et al.* 2007). In a study of 500 samples of white beans from the Iranian National Plant Gene Bank by path analysis, it was determined that the number of pods per plant, the weight of 100 seeds, and the number of seeds per plant had the greatest effect

Table 5. Direct and indirect effects of traits on the grain yield per plant in Chitti bean lines.

Trait	V_2	V_3	V_4	Branches per plant	Pods per plant	Seeds per pod
V_2	0.007	0.006**	0.006**	-0.002**	-0.002**	0.000
V_3	-0.401**	-0.428*	0.379**	0.106**	0.101*	-0.007
V_4	-0.108**	-0.108**	-0.122	0.032**	0.026**	-0.009
Branches per plant	-0.017**	-0.015**	-0.016**	0.063	0.036**	-0.008
Pods per plant	-0.017**	-0.016**	-0.014**	0.038**	0.067	-0.005
Seeds per pod	0.007	0.004	0.017	-0.031	-0.018	0.231**

* and ** are significant at the 5% and 1% levels of probability, respectively.
V_2: Days to the emergence of primary leaves; V_3: Days to the emergence of the first trifoliate leaf; V_4: Days to the emergence of the third trifoliate leaf.

on improving grain yield (Dargahi *et al.* 2008). Also, in Molaei *et al.* (2005), the number of seeds per pod had the highest direct and positive effects on grain yield, and this trait was proposed as the best standard for indirect selection for increasing grain yield. Another study was conducted to identify the direct and indirect effects of different traits on grain yield and it was determined that seed number per plant and 100 seed weight had the highest direct and positive effects on grain yield (Soghani *et al.* 2010). Cokkizgin *et al.* (2013) also showed that the number of seeds per plant had the highest direct effect on grain yield. In another study, path analysis showed that the number of pods per plant had the highest direct effect on yield, followed by plant height, the number of branches per plant, and the number of days to 50% flowering (Arya *et al.* 1999). Singh (2001) determined the path coefficients for common bean and concluded that the number of pods per plant, the number of seeds per pod, and grain size had direct effects on yield. In another study, the correlation between yield and yield components in cowpea showed the highest direct effects of seeds per pod and 100 seed weight on grain yield (Aggarwal *et al.* 1982).

Cluster analysis: The cluster analysis separated the 119 genotypes into four distinct groups (Table 6). There were 100 lines in the first cluster, 11 lines as well as three checks in the second cluster, two lines in the third cluster, and three lines in the fourth cluster (Figure 1). In the first group 100 genotypes, in the second group 14 genotypes (1, 2, 3, 8, 12, 13, 20, 52, 76, 87, 88, 89, 90, 91), in the third group two genotypes (97, 108), and in the fourth group three genotypes (18, 65, 85) were included. All the fourth and third group genotypes had the plant type 1. In the second group, except genotype 52, all genotypes had plant types 2 and 3. Most genotypes of the first group had type 1. The genotypes of the first group were superior to other genotypes in terms of 100-seed weight and grain yield. Therefore, genotypes of this group can be used to increase grain size. Also, the genotypes of the first group were earlier than other genotypes and the use of these genotypes to create early mature cultivars can be considered by

Table 6. Results of the mean comparison of clusters for different traits of 119 Chitti bean genotypes.

Trait	Clusters				Mean	Std. Deviation
	1	2	3	4		
V_2	16.0 b	15.0 b	11.0 c	18.0 a	15.00	2.94
V_3	19.0 a	19.0 a	16.5 b	20.0 a	18.62	1.49
V_4	27.0 b	27.0 b	25.0 c	29.0 a	27.00	1.63
R_5	41.0 c	43.0 b	53.0 a	44.0 b	45.25	5.31
R_6	53.0 b	53.0 b	86.5 a	52.7 b	61.30	16.80
R_7	60.0 b	62.0 b	92.0 a	62.7 b	69.17	15.25
R_8	95.0 c	95.0 c	110.0 a	100.0 b	100.00	7.07
R_9	103.0 c	104.0 c	121.0 a	109.0 b	109.25	8.26
Plant height (cm)	49.0 d	96.0 a	72.5 b	54.3 c	67.95	21.22
Branches per plant	6.0 b	5.0 c	7.0 ab	7.7 a	6.44	1.20
Pods per plant	16.0 b	15.0 b	16.5 b	29.2 a	19.17	6.71
Pod length (cm)	12.0 ab	11.0 b	11.5 ab	12.5 a	11.75	0.64
Seeds per pod	5.0 a	4.0 b	4.2 b	5.1 a	4.57	0.53
Seeds per plant	67.0 b	62.0 b	52.5 c	143.4 a	81.23	41.90
100-seed weight (g)	46.0 a	42.0 b	45.5 ab	45.2 ab	44.69	1.81
Grain yield per plant (g)	21.0 a	15.0 c	14.5 c	18.6 b	17.30	3.07

The same letters in each row show no significant difference between the clusters at the 5% level by Duncan's method.

breeders. The genotypes of the second group were superior only in terms of plant height. Increasing the plant height in a balanced way, if it is accompanied by increasing the stem diameter, is considered as an advantage in increasing yield due to the increase in leaf area and its better distribution in the plant canopy, and it has a positive effect on weed control, especially at the beginning of the growing season (Soghani *et al.* 2010). This trait is an important character in beans. Although prostrate cultivars, which have higher plant height and usually produce more yield, nevertheless, in the bean breeding program, the goal is to create bush-type cultivars with mechanized harvesting capability.

The genotypes of the third group were different from other genotypes in terms of reproductive growth stages (days to floral initiation, days to flowering, days to pod formation, days to pod filling, days to maturity). These genotypes reached these stages later, meaning that the reproductive growth period in this group was longer. Due to the fact that one of the important traits in the bean breeding program is early maturity, the genotypes in the third group are not suitable in terms of days to maturity. The genotypes in the fourth group were different from other genotypes in terms of vegetative growth stages (days to emergence of primary leaves, days to emergence of the first trifoliate leaf, days to emergence of the third trifoliate leaf). The genotypes of this group reached the mentioned stages later, in other words, the growing period in these genotypes was longer. Also, the genotypes of this group were superior to the other genotypes in terms of number of branches per plant, number of pods per plant, number of seeds per pod, number of seeds per plant, and pod length. These traits, which are considered yield components, can be used in bean breeding programs to increase grain yield. This group had the highest grain yield after the first group. Therefore, due to the

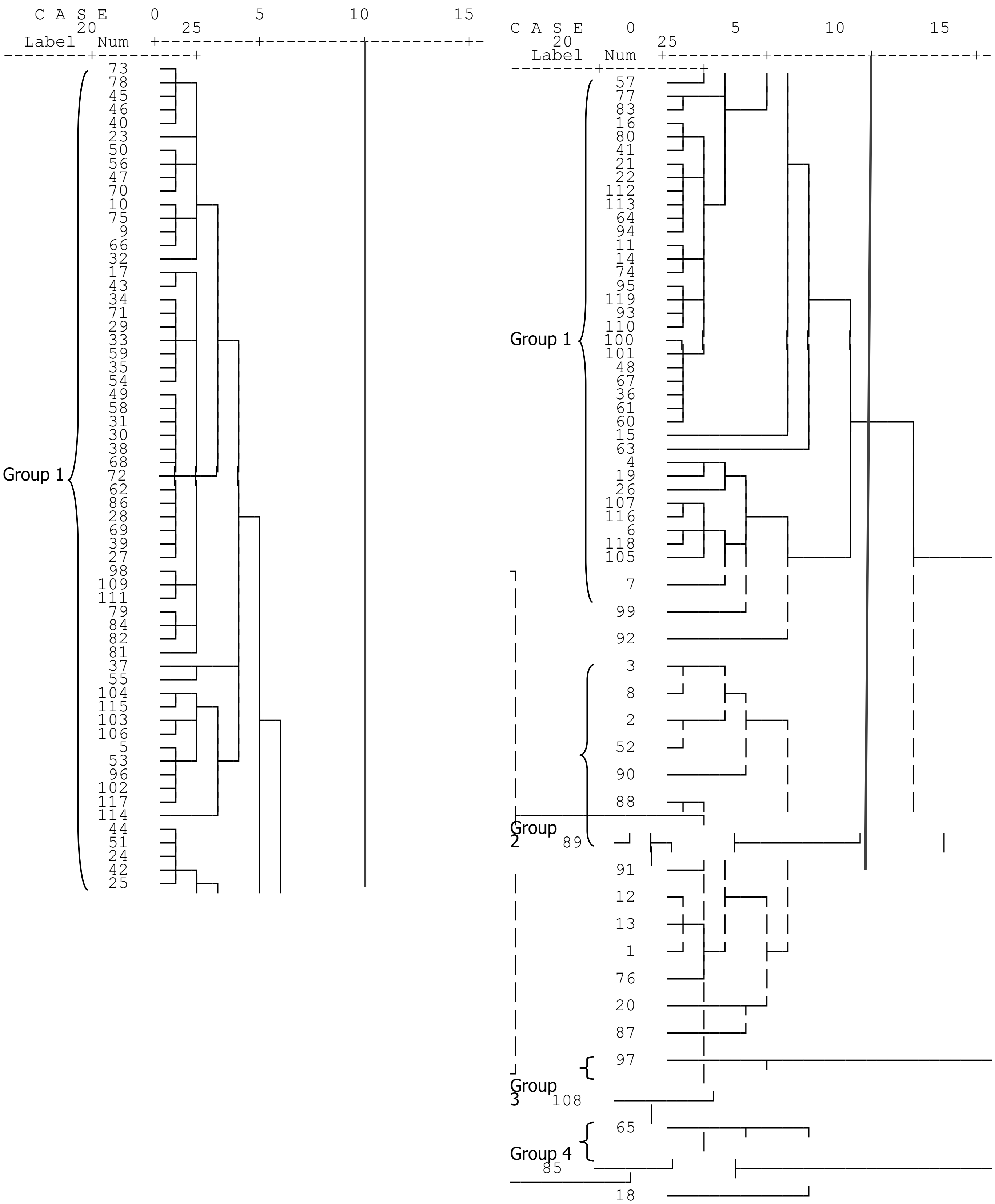

Figure 1. The dendrogram from the cluster analysis of the Chitti bean lines by UPGMA method.

multiplicity of desirable traits in this group, these genotypes can be used to improve the yield of Chitti beans.

Amini *et al.* (2000) analyzed 576 genotypes of the common bean by using cluster analysis and classified the samples into seven distinct groups. Ebrahimi *et al.* (2010) also studied the genotypes of beans in terms of phenological-agronomic traits by cluster analysis using the UPGMA method and classified them into three groups. Shafiee-Koyej and Saba (2013) used cluster analysis of phenological and agronomic traits in beans and classified the genotypes into three groups, early maturing with high yield and yield components, late-maturing with high yield and yield components, and early maturing with low yield and yield components. The use of cluster analysis of traits by Ward's method in Javadin and Nakhjavan (2013) study helped them to classify genotypes into five groups. Ulukapi and Naci Onus (2014) also evaluated 36 genotypes of green beans in Turkey for morphological and physiological traits, and using cluster analysis, they succeeded to classify the genotypes into eight distinct groups.

According to the results of present study, 38 genotypes (numbers 7, 16, 18, 22, 29, 30, 32, 34, 36, 39, 45, 54, 58, 59, 61, 62, 64, 68, 70, 79, 81, 82, 84, 85, 88, 91, 94, 96, 99, 100, 101, 102, 105, 110, 111, 113, 118) were better genotypes in for grain yield, 100-seed weight, plant type, and grain marketing. Of these, 33 genotypes belonged to the first cluster, two genotypes belonged to the second cluster and two genotypes belonged to the fourth cluster.

Conclusions

The 116 bean lines evaluated showed significant differences in growth stages, yield, and yield components. Grain yield and seed number per plant had the highest phenotypic coefficients of variation. The number of days to emergence of the first trifoliate leaf with negative coefficient and number of seeds per pod with positive coefficient were the most effective factors that directly affected grain yield and these traits can be useful for Chitti bean breeding programs. From the genotypes studied in this experiment, 38 superior genotypes were selected. So, it is possible to use these lines or in the breeding programs of Chitti bean and use the traits such as the number of days to emergence of the first trifoliate leaf and the number of seeds per pod to increase the grain yield of Chitti bean.

Conflict of Interest

The authors declare that they have no conflict of interest with any people or organization concerning the subject of the manuscript.

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References

Aggarwal VD, Natare RB, and Smithson JB, 1982. The relationship among yield and other characters in vegetable cowpea and the effect of different trellis management on pod yield. Tropical Grain Legume Bulletin 25: 8-14.

Amini A, Ghannadha MR, and Abdemishani S, 2000. Factor analysis for morphological and phenological traits in common bean. Seed and Plant Journal 16: 210-225 (In Persian with English abstract).

Arunachalam V, 1981. Genetic divergence in plant breeding. Indian Journal of Genetics and Plant Breeding 41: 226-236.

Arya PS, Rana A, and Rana A, 1999. Study of direct and indirect influence of some yield traits on green pod yield in French bean (*Phaseolus vulgaris* L.). Advances in Horticulture and Forestry 6: 99-106.

Awan FK, Khurshid MY, Afzal O, Ahmed M, and Chaudhry AN, 2014. Agro-morphological evaluation of some exotic common bean (*Phaseolus vulgaris* L.) genotypes under rainfed conditions of Islamabad, Pakistan. Pakistan Journal of Botany 46: 259-264.

Azizi F, Rezaei A, and Mirmohammadi Maybodi SAM, 2001. Genetic and phenotypic variability and factor analysis for morphological traits in genotypes of common bean (*Phaseolus vulgaris* L.). Journal of Science and Technology of Agriculture and Natural Resources-Water and Soil Science 5: 127-141 (In Persian with English abstract).

Blair MW, Díaz LM, Buendía HF, and Duque MC, 2009. Genetic diversity, seed size associations, and population structure of a core collection of common beans (*Phaseolus vulgaris* L.). Theoretical and Applied Genetics 119: 955-72.

Chiorato AF, Carbonell SAM, Benchimo LL, Chiavegato MB, Dos Santos Dias LA, and Colombo CA, 2007. Genetic diversity in common bean accessions evaluated by means of morpho-agronomical and RAPD data. Scientia Agricola 64: 256-262.

Chiorato AF, Carbonell SAM, Colombo CA, Dias LAS, and Ito MF, 2005. Genetic diversity of common beans accessions in the germplasm bank of the Instituto Agronômico– IAC. Crop Breeding and Applied Biotechnology 5: 1-9.

Cokkizgin A, Colkesen M, Idikut L, Ozsisli B, and Girgel U, 2013. Determination of relationships between yield components in bean by using path coefficient analysis. Greener Journal of Agricultural Science 3: 85-89.

Dargahi HR, Vaezi S, Omidi M, and Aghaei MJ, 2008. An evaluation of the diversity in morphological traits and an identification of the relationships among these traits of white common bean collected in national plant gene bank of Iran. Iranian Journal of Field Crops Science 39: 155-162 (In Persian with English abstract).

Ebrahimi M, Bihamta MR, Hoseinzade A, Khial Parast F, and Golbashy M, 2010. Evaluation of yield and yield components and some agronomic traits of white bean (*Phaseolus vulgaris* L.) genotypes under Karaj climate. Agroecology 2: 129-135 (In Persian with English abstract).

Farshadfar E, 1997. Breeding methodology. University of Kermanshah, Iran (In Persian).

Ghanbari AA, 2015. Preliminary evaluation of bean (*Phaseolus vulgaris)* germplasm. Seed and Plant Improvement Institute (SPII), Karaj, Iran. Project No. 2-03-03-93160.

Javadin M and Nakhjavan Sh, 2013. Classification of some Chitti bean genotypes based on the morphological and phenological traits using multivariate statistical methods. Proceedings of the 5th Iranian Pulse Crops Symposium, February 25, University of Tehran, Karaj, Iran (In Persian).

Keshavarznia R, Mohammadi Nargesi B, and Abbasi A, 2013. The study of genetic variation of bean (*Phaseolus vulgaris* L.) based on morphological traits under normal and stress conditions. Iranian Journal of Field Crops Science 44: 305-315 (In Persian with English abstract).

Molaei A, Ghaffari Khaligh H, and Bagheri H, 2005. A correlation and path coefficient analysis between seed yield and its components in common bean. Proceedings of the 1st Iranian Pulse Crops Symposium, November 20-21, Ferdowsi University, Mashhad, Iran (In Persian).

Rahnamaie Tak A, Vaezi S, Mozafari J, and Shahnejat Bushehri AA, 2007. Study on correlation and path analysis for seed yield per plant and its dependent traits in red bean (*Phaseolus vulgaris* L.). Agronomy Journal 76: 80-88 (In Persian with English abstract).

Safapour M, Khagani S, Amirabadi M, Teymouri M, and Bazyan MK, 2009. Statistical analysis of the effect of water stress on phenological and agronomical traits of white bean genotypes. New Agriculture Findings 4: 367-378 (In Persian with English abstract).

Sanjeev Deshpand K, Patil BR, Salimath PM, Nidagundi JM, and Karthigeyan S, 2010. Evaluation of native and collected germplasm for earliness seed traits and resistance to rust, CMV, and leaf spot in cowpea [*Vigna unguiculata* (L.) Walp]. Electronic Journal of Plant Breeding 1: 384-392.

Shafiee-Koyej F and Saba J, 2013. Evaluation of white bean lines based on phenological and agronomic traits using multivariate statistical methods. Iranian Journal of Crop Science 14: 383-394 (In Persian with English abstract).

Singh SP, 2001. Broadening the genetic base of common bean cultivars. Crop Science 41: 1659-1675.

Soghani M, Vaezi S, and Sabbaghpour SH, 2010. Study on correlation and path analysis for seed yield and its dependent traits in white bean genotypes (*Phaseolus vulgaris* L.). Agronomy and Plant Breeding Journal 6: 27-36 (In Persian with English abstract).

Ulukapi K and Naci Onus A, 2014. Phenotypic evaluation of some Turkish green bean (*Phaseolus vulgaris* l.) genotypes. Pakistan Journal of Botany 46: 1415-1420.

Vasi M, Gvozdanovi-Varga J, and Ervenski J, 2008. Divergence in the dry bean collection by principal component analysis (PCA). Genetika 40: 23 -30.

ارزیابی صفات زراعی-مورفولوژیکی لاین‌های لوبیا چیتی با استفاده از روش‌های آماری چندمتغیره

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چکیده

به‌منظور بررسی صفات کمی و کیفی ۱۱۶ لاین لوبیا چیتی، آزمایشی با سه شاهد (صدری، کوشا، محلی خمین) با استفاده از یک طرح اوگمنتد اجرا شد. بررسی نتایج نشان داد که عملکرد دانه و تعداد دانه در بوته از بیشترین تغییرات برخوردار بودند. تجزیه رگرسیون صفات حاکی از آن بود که تعداد روز تا سه برگچه اول، تعداد دانه در غلاف و ارتفاع بوته بیش از ۳۹ درصد تغییرات عملکرد را توجیه کردند. تجزیه علیت صفات نشان داد که تعداد روز تا ظهور سه‌برگچه اول و ارتفاع بوته با ضریب منفی و تعداد دانه در غلاف با ضریب مثبت مؤثرترین عوامل مستقیم تغییرات عملکرد دانه هستند. تجزیه خوشه‌ای صفات لاین‌ها را در چهار گروه مجزا قرار داد. از بین ژنوتیپ‌های مورد مطالعه، ۳۸ ژنوتیپ برتر انتخاب شدند که می‌توان از آن‌ها در برنامه‌های اصلاحی لوبیا چیتی استفاده کرد. همچنین برای افزایش عملکرد می‌توان از صفاتی مانند تعداد روز تا ظهور سه‌برگچه اول و تعداد دانه در غلاف در برنامه‌های اصلاحی لوبیا چیتی استفاده نمود.

واژه‌های کلیدی: تجزیه چند متغیره؛ تعداد دانه در غلاف؛ تعداد غلاف در بوته؛ عملکرد و اجزای عملکرد؛ لوبیا