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Genetic diversity evaluation of different varieties of soybean (*Glycine max* L.) based on morphological traits

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Abstract

Present of enough genetic diversity increases efficiency of selection in breeding programs. In order to study of genetic diversity for yield and its components, number of 14 soybean Genotypes and a local check variety (JK) were planted in a randomized complete block design with three replications in 2013. Different traits such as plant height (cm), height of the first secondary stem (cm), number of secondary stems, number of pods in secondary stems, number of pods in main stem, number of grain per plant, 100-grain weight (gr), pod length (cm), yield per plant (gr) and yield (kg/ha) were investigated. Results of analysis of variance showed significant difference for the traits except number of secondary stems. The highest CV was for yield per plant, number of pod in secondary stems, height of the first secondary stem and 100-grain weight which are respectively 29.64, 28.99, 27.45 and 26.79. The lowest CV was for number of secondary stems and plant height that are respectively 14.37, 14.78 and 15.46. Emperor and Kao-hsiung-10 genotypes had the highest (5113 kg/ha) and lowest (2060 kg/ha) yield, respectively. The cluster analysis of soybean genotypes has been divided into five groups based on morphologic traits including seeds weight per plant (gr), pods length (cm), weight of 100 seeds (gr) and yield (kg/ha).

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Introduction

Genetic diversity and selection are two main components of any modifying program and selection has high efficiency, in case there is a desirable diversity in yield traits (kg per hectare) genetically. Soya is annual, self-fertile plant with the scientific name Glycine max from Fabaes order with diploid (2X = 2n = 40) (10). Its agronomic type is Gis*laycine max* L. Merr. Due to its high quality, soya is a unique crop. Soybean consists of 20 to 24 percent of oil and 40 to 44 percent protein and is ranked first in the world in oil production (16). Regarding the economical position and importance of soya in Iran and in the world, in order to gain higher yield of the bean p/m2. And increasing the bean oil, in addition to increasing its field cultivation, using modifying plans and extensive research will be useful.

Genetic diversity is an essential requirement for progress in plant breeding (9, 10, 12). Breeders usually use genetic diversity for selecting desirable traits in order to improve grain yield. A breeder can have chance of success in the modification plans in case there is diversity and opportunity for adopting desirable materials. Regarding this point different studies have been done by incorporating correlation between traits in order to investigate the relationship between morphologic traits and also type and extent of its impact on grain yield (9,10 and12).

Correlation between traits is of high importance, because such correlations can help the breeder in indirect selection of important traits through less important traits, which are easier to select (4).Considering different investigations, there is a desirable and satisfying diversity in heritability regarding all traits and the purpose of this study is to investigate the genetic diversity of some soya orders based on agronomic and morphologic traits and how these traits are correlated with yield traits and in the end investigating the grouping of these genotypes in order to use such orders in modification plans.

Henrique *et al* (2004) reported that there is a significant correlation between yield and traits of seed number and traits of number of pods per plant, and these traits are the most important traits correlated with yield. Singh and Yadava (2000) reported that there is a positive and significant correlation between grain yield in plant and numbers of pods and seeds in plant. They also indicated high genotyical diversity in the traits number of seeds per plant, plant height, number of pods per plant, number of branches per plant. Bizet *et al* (2004) studied 9 genotypes of soya in the greenhouse condition and reported that number of nodes and number of pods per plant correlated positively and significantly with yield.

Board (1987) by studying 8 cultivars of soya for two years and the correlation of grain yield with numbers of grain per plant for two years reported the number of nodes and pods per plant respectively 0.69, 0.56 and 0.53 Myers and Singh (1989) studied 440 soybean cultivars for some qualitative and quantitative traits in India and observed a high diversity for plant height, number of breeding branches, number of pods per plant and weight of 100 grains. Mahajan *et al* (1994) having investigated 51 agronomic soya cultivars, reported high variation coefficient for grain number traits per plant, plant height, number of pods per plant, number of branches per plant. Arshad *et al* (2006) studied 32 soya genotypes, in which grain yield correlated positively and significantly with pod length, 1000 seed weight, number of sub branches and number of pods.

Taware *et al* (1997) studied 6 lines of soybean and first generation of hybrid in them. There was a high genotypic variation coefficient in plant height, number of pods and seeds per plan. There was a positive and significant correlation between grain yield per plant and plant height, number of sub branches, pods and number of seeds per plant. Singh and Labana (1990) reported that grain yield per plant correlated positively and significantly with number of pods per plant, grains per pod and 100 seed weight. Chettri *et al* (2003) studied 18 elite soybean genotypes for three years and revealed that grain yield correlated positively and significantly with numbers of grains in pod. Show Kat *et al* (2010) reported that number of pods per plant, seeds per pod and 100 seed weight correlated positively with grain yield. Sudaric *et al* (2002) studied 22 genotypes of soybean and revealed low variation for grain traits per plant, number of nodes per plant and number of seeds per plant. Bangar *et al* (2003) studied 16 soybean genotypes and revealed that phonotypical and genotypic variation coefficient for number of sub branches and plant height were more than other traits.

Therefore, the aim of this experiment was to evaluate the genetic diversity for yield and its components of 15 soybean genotypes.

Materials and methods

Plant materials and experimental design

Materials used in this study includes 14 advanced soybean lines and genotypes with Mazandaran local Control cultivar, which have been collected from oilseed research Centre in Mazandaran province, Sari county (Table 1).

Table 1. List of genotypes under study in this test.

Provenance	Types of Name	Code	provenance	Types of Name	Code	provenance	Types of Name	Code
Iran	Sahar	G11	USA	Emperor	G6	Iran	753	G1
USA	Saline	G12	USA	Er-hej-jan	G7	Iran	795	G2
Australia	Semmes	G13	Australia	Improved hood	G8	Australia	Bedford	G3
UK	UK150	G14	Iran	JK (Control)	G9	Australia	Centaur	G4
Australia	York	G15	Australia	Kao hsiung 10	G10	Australia	CM	G5

This test has been implemented through randomized complete blocks design with three replications in 1392. The cultivation was done compatible in accordance with. After preparing the field to the extent needed, a mixture of phosphorus and potash chemical fertilizer with the ratio 1: 1 and the amount of 5 kg was used before cultivation. In order to fight off narrow-leaf weeds in the field, Supergalant herbicide was used with the amount of two in thousand and to fight off pests such as Aphids and mites in the field Apamtkyn was used with the amount of one in thousand.

Estimated characters

Measurement of different traits like plant height, height of first sub branch, number of sub branch, sub branch pod, main branch pod, number of seeds per plant, 100 seed weight, length of pod, weight of grain per plant and yield (kg in hectare) was done in accordance with the instruction stated by Sharma (1971) and Shiva Shankar (1989).

Statistical analysis

Comparing the means of the data was done based on Duncan's multiple comparison. In addition, cluster analysis for data grouping and correlation analysis for specifying the relationship between the traits were done through SPSS software.

Results and discussion

Analysis of variance and mean comparison

Results of variance analysis showed that there was a significant difference between genotypes under study in terms of plant height, height of first sub branch, sub branch pod, main branch pod, number of seeds per plant, length of pod, weight of seed per plant and grain yield which reveals enough genetic diversity between existing genotypes regarding these traits (Table 2).

Comparing the means of different traits for the soybean genotypes under the study indicated that plant height with genotypes G 10,G3,G2 was the most ($\bar{y}$= 135.67 , $\bar{y}$ = 124.67 and $\bar{y}$ = 124.33 cm, respectively) and genotype G6 was minimum ($\bar{y}$ = 68.33 cm). With attention to the point that having less height is considered in soybean modification due to lack of lodging and more yield, hence genotype G is desirable in this regard (Table 3). Regarding trait of first sub branch height, genotypes G13 ,G9 ,G2 are the most (ȳ = 11.66, ȳ = 9.1 and ȳ = 8.83 cm, respectively) and the minimum height of first sub branch is for genotypes G 5,G 10 and G 15 (respectively ȳ = 4.16, ȳ = 4.4 and ȳ = 5.6 cm) . The height of first sub branch is considered one of the significant agronomic traits harvesting with combine, which the nearer it is to the surface of the field, the more efficient mechanized harvest will be (Table3).

Table 2. Variance analysis Yield related components in soybean cultivars.

Source of Variations	Df	M-s									
		plant height (cm)	height the first secondary stem(cm)	number of secondary stems	number of pods in secondary stems	number of pods in main stem	number of grain per plant	100-grain weight (gr)	pod length (cm)	yield per plant (gr)	yield (kg/ha)
Block	2	3.82^{ns}	2.93^{*}	2.75^{ns}	4.42^{ns}	6.86^{ns}	484.28^{ns}	4.06^{*}	0.086^{ns}	15.3^{ns}	2001.62^{ns}
Genotypes	14	775.4^{**}	11.86^{**}	1.17^{ns}	361.32^{**}	130.03^{**}	2097.21	86.91^{**}	3.11^{**}	291.62^{**}	2902464.97^{**}
error	28	4.7	0.63	0.89	3.23	6.53	192.12	0.89	0.1	5.41	1278.64
CV (%)		4.32	8.7	20.99	8.53	15.97	12.36	4.43	2.36	15.45	38.50

* . ** and ns: In order of significance at the probability levels 5 and 1% and insignificance

Table 3. comparisons of the means of different morphological traits in soybean cultivars under the study.

Traits genotype	plant height (cm)	height the first secondary stem(cm)	number of secondary stems	number of pods in secondary stems	number of pods in main stem	number of grain per plant	100-grain weight (gr)	pod length (cm)	yield per plant (gr)	yield (kg/ha)
G1	110^{d}	6.66^{de}	4	26.33^{ij}	46.33^{b}	179.67^{bcd}	26.24^{b}	4^{cde}	44.78^{c}	4478.3^{c}
G2	124.33^{b}	8.83^{b}	4.33	31.66^{g}	40.66^{cde}	203^{ab}	20.7^{cde}	4.66^{b}	40.11^{e}	4011^{e}
G3	124.67^{b}	6^{def}	4	31.33^{g}	41.66^{bcd}	165.33^{cde}	14.8^{g}	4.7^{b}	24.07^{k}	2407^{k}
G4	109^{d}	7.33^{cd}	4.33	27^{hi}	35^{gh}	158^{def}	18.46^{f}	3.73^{ef}	26.39^{i}	2639^{i}
G5	101.33^{e}	4.16^{h}	3.33	23.33^{j}	29.33^{h}	119.67^{g}	19.91^{def}	3.16^{fg}	24.11^{k}	2411^{k}
G6	68.33^{g}	8.26^{bc}	4.66	44^{cd}	42.66^{bcd}	158.67^{def}	34.30^{a}	7.43^{a}	51.13^{a}	5113^{a}
G7	121.33^{b}	8.2^{bc}	3	32^{g}	39.66^{def}	177.67^{bcd}	15.28^{g}	3.83^{de}	26.45^{i}	2645^{i}
G8	114^{c}	7.2^{cde}	5	40.33^{e}	34^{g}	190^{bc}	19.43^{ef}	4.43^{bcd}	36.14^{f}	3614^{f}
G9	110.67^{cd}	9.1^{b}	5.33	65.33^{a}	35^{fg}	176^{cd}	21.49^{cd}	4.4^{bcd}	35.56^{f}	3556^{f}
G10	135.67^{a}	4.4^{gh}	3.66	41^{de}	37.33^{efg}	141.67^{efg}	13.19^{h}	3.03^{g}	20.60^{m}	2060^{m}
G11	97.66^{e}	8.63^{bc}	4	30^{gh}	44.33^{bcd}	134^{fg}	16.01^{g}	3.5^{efg}	22.17^{l}	2217^{l}
G12	101^{e}	5.76^{efg}	4.66	46.66^{bc}	45.33^{bc}	223.33^{a}	21.99^{c}	3.96^{cde}	45.77^{b}	4577^{b}
G13	107.67^{d}	11.66^{a}	4.66	43.66^{cd}	52.66^{a}	172.33^{cd}	18.57^{f}	3.93^{cde}	30.54^{g}	3054^{g}
G14	114.33^{c}	7.23^{cde}	4.33	36^{f}	37^{efg}	186.33^{bc}	15.9^{g}	4.1^{bcde}	27.20^{h}	2720^{h}
G15	91.33^{f}	5.6^{fgh}	4.33	49^{b}	52^{a}	179^{bcd}	24.8^{b}	4.46^{bc}	43.09^{d}	4309^{d}

In each column the means with the similar letters do not differ significantly in regarding to Duncan's multiple test.

Maximum number of pods in the sub branches is for genotypes G9, G15 and G12 (ȳ = 65.33, ȳ = 49 and ȳ = 46.66, respectively) and the minimum number of pods in sub branches is for genotypes G5, G1 and G11 (ȳ = 23.33, 33/26 ȳ = 26.33 and ȳ = 30, respectively), the more the pods in sub branches, the more the yield will be (Table 3).

Regarding the traits of pods in main branch, genotypes G13, G15 and G1 maximum (ȳ = 52.66, ȳ = 52 and ȳ = 46.33, respectively) and the minimum is for genotypes G8, G9 and G4 (ȳ = 34, ȳ = 35 and ȳ = 35, respectively).This trait is of the main components of soybean yield. Regarding number of seeds per plant, genotypes G12 and G2 have maximum seeds per plant ȳ = 223.33 and ȳ = 203, (respectively) and the minimum number of seeds per plant is for genotypes G5 and G11 (respectively ȳ = 119.67 and ȳ = 134), considering that the more the number of grain per plant, the more the weight of grain will be, which in fact increases the yield (table 3).

Principally when seeds increases in plants, grains become smaller and 100 seed weight reduces.

Regarding 100 seed weight trait genotype G6 with the average of (ȳ = 34.30g) has superiority over other genotypes and genotypes G3, G7 and G14 (ȳ = 14.8, ȳ = 15.28 and ȳ = 15.9 gr, respectively) had the minimum 100 seed trait. It is therefore concluded that when the weight of 100 seed increases, the yield increases as a result (table 3). Mishra te al (1994) stated the direct effect of 100 seed weight on soybean yield. Regarding pod length trait, genotype G6 with the average of (ȳ = 7.43) was ranked first amongst the genotypes under the study, that the more the length of pod, the larger the grain in the pod will be, which increases 100 seed weight and grain weight per plant and as a result increases the yield.(Table 3).

Overally, it is possible to conclude that genotype G6 with the yield 5113 kg in hectare has the maximum yield and the genotypes G10 and G11 respectively with the yield 2060 and 2201 kg in hectare have the minimum yield among the other genotypes (Table 3), which these results are in agreement with Sutigihno and Sudjono (1992).

Considering the results reported by Sharma *et al* (1971) and Diascarrasco *et al* (1987), traits like plant height, height of primary sub branch is of important traits in increasing soybean yield.

Considering that maximum variation coefficient for the traits of grain weight per plant, number of sub branch pods, height of primary sub branch and 100 seed weight are respectively 29.64, 28.99, 27.45 and 26.79 which show high genetic diversity in the traits under the study. Hence efficiency of selection in modification plans for these traits are high. But sub branch number traits, height of plant, number of grains per plant are respectively 14.37, 14.78 and 15.46 have minimum variation coefficient compared to other traits, which show low genetic diversity in these traits (Table 4).

Table 4. descriptive statistics of the traits under study for different genotypes of soybean.

Traits	mean	Standard deviation	minimum	Maximum	Coefficient of Variation
plant height (cm)	108.76	16.08	68	135	14.78
height the first secondary stem(cm)	7.24	1.98	4.17	11.67	27.45
number of secondary stems	4.22	0.61	3	5.33	14.37
number of pods in secondary stems	37.84	10.97	23.33	65.33	28.99
number of pods in main stem	40.87	6.58	29.33	52	16.11
number of grain per plan	170.98	26.43	119.17	223.33	15.46
100-grain weight (gr)	20.09	5.38	13.2	34.33	26.79
pod length (cm)	4.22	0.26	3.03	7.43	24.11
yield per plant (gr)	33.25	9.85	20.6	51.13	29.64
yield (kg/ha)	3320.97	985.93	2060	5113	29.64

Table 5. correlation between morphologic traits in soybean genotypes.

line	plant height (cm)	height the first secondary stem(cm)	number of secondary stems	number of pods in secondary stems	number of pods in main stem	number of grain per plant	100-grain weight (gr)	pod length (cm)	yield per plant (gr)	yield (kg/ha)
1	1									
2	-0.107	1								
3	-0.293	0.411	1							
4	-0.192	0.229	0.692**	1						
5	-0.291	0.316	0.139	0.203	1					
6	-0.109	0.212	0.464	0.35	0.316	1				
7	-0.793**	0.078	0.393	0.253	0.276	0.172	1			
8	-0.601*	0.27	0.429	0.292	0.194	0.214	0.751**	1		
9	-0.571*	0.099	0.507	0.379	0.406	0.588*	0.885**	0.668**	1	
10	-0.571*	0.099	0.507	0.379	0.406	0.588*	0.885**	0.668**	1.00**	1

*/ ** In order of significance at the probability levels of 5 and 1%

Results of the correlation shows that soybean yield correlates positively and significantly with number of grains per plant (r = 0.588), 100 seed weight (r = 0.885), pod length (r = 0.668) and weight of seed per plant (r =1.000). Also yield correlates negatively and significantly with plant height. On the other hand plant height showed negative and significant correlation with 100 seed weight (p = 0.793), pod length (p = 0.601), (Table 5).

Simple correlation analysis

The phenotypic correlation coefficients indicated that grain yield correlated significantly with all traits except number of seeds per pod and number of fertile branches. Number of days from emergence to maturity, plant height, number of breeding branches, number of pods per plant correlated positively and significantly with one another and with grain yield, but they correlated negatively with 100 seed weight. Henrique *et al* (2004) reported that yield correlates significantly with the traits of the number of seeds per plant and number of pods per plant that represents these are outstanding correlated traits of grain yield. Similar results were reported by Shiva Shankar and Viswanatha (1989) and Taware *et al* (1997) for number of pods per plant and by Akhter and Sneller (1996) for number of seeds per plant.

Cluster analysis

Cluster analysis through ward's minimum variance indicated that genotypes under the study were divided into 5 main group, where in group one number of 5 genotypes (G1, G2, G8, G12, and G15), in group two, 2 genotypes (G9 and G13), in group three, 1 genotype (G6), in group four, 3 genotypes (G5, G10 and G11) and in group five, 5 genotypes G3, G4, G7 and G14) were used (Fig. 1).

Cluster analysis have placed genotypes G1, G2, G8, G12, and G15, which have yield, weight of grain per plant, length of pod and 100 seed weight more than groups 2, 4 and 5 in group one, and genotypes G9 and G13, which have yield, weight of grain per plant, length of pod and 100 seed weight more than groups 4 and five in group two, and genotypes G6 which has the maximum yield, seed weight per plant (g), pod length (cm) and 100 seed weight (g) alone in group 3, genotypes G11, G5 and G10 which have minimum yield, seed weight per plant, length of pod and 100 seed weight in group 4 and finally genotypes G3, G4, G7 and G14 which have more yield compared to group four in group 5 (Fig. 1).

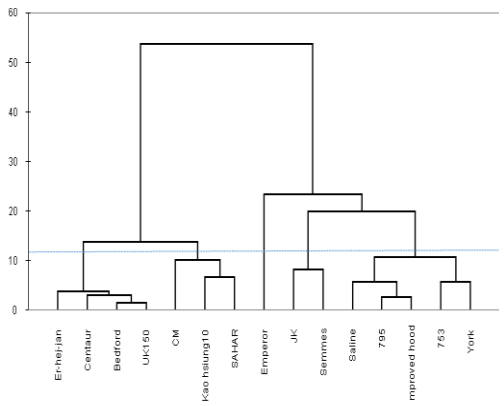

Fig. 1. Grouping of soybean genotypes with ward's minimum variance for morphologic traits.

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