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Study on genetic variation of 14 soybean cultivars using cluster and factor analysis under water stress and non-stress conditions

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Key words: Soybean, Cluster analysis, Factor analysis, water stress.

Abstract

This experiment was conducted in Mahidasht Agricultural Research Station in the west part of Iran in RCBD with three replications under normal and drought stress conditions. The cluster analysis based on ward method showed the cultivars were grouped by four clusters under non-stress condition. The cultivars of clusters were including; (I: Baj-maj); (II: M_9, Hy-1 and LD_9); (III: The fertile cultivars as L_{17}, Union, Bonus, Williams, Steel, Elgine, Clark) and (IV: The infertile cultivars as Hack, Flanklin and Halcor) respectively; While they were grouped by three clusters under stress condition. These cultivars of clusters were including (I: The infertile cultivars as Baj-maj, Steel, Williams, Bonus, Hack, Halcor and Flanklin); (II: The cultivars as Hy-1, Elgine and M_9); (III: The fertile cultivars as Clark, LD_9, L_{17}, Clark and Union); respectively. The evaluation of discriminate function on 14 soybean cultivars under non-stress condition showed 3 functions with eigenvalues more than 1 explained totally 100% of cultivar variations. The evaluation of discriminate function on 14 soybean cultivars under stress condition showed 2 functions with eigenvalues more than 1 explained totally 100% of cultivar variations. In factor analysis on 9 traits under non-stress condition, there were three components with 73.86% of traits variation with varimax rotation method. The contribution of first, second and third components were 38.08%, 20.56% and 15.21%, respectively. On the other hand three components explained 74.79% of traits variation with varimax rotation method under stress condition. The contribution of first, second and third components were 32.57%, 27.20 and 15.02 respectively. The cluster analysis based on wards method showed four clusters of traits in both stress and non-stress conditions.

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Introduction

The study of genetic variation can be used either for selecting superior genotypes that be utilized as parents for development of future cultivars through hybridization. Many methods are available now for studying genetic variability among accessions such as total seed protein, isozymes and various types of molecular markers. However, morphological characterization is the first step in the description and classification of genotypes (Smith & Smith, 1989; Rabbani *et al*., 1998). Genetic variability is still believed by all plant scientists. The importance of genetic diversity and scope of plant genetic improvement through the manipulation of available traits in plant breeding is obvious from the obtained results in different crops (Smartt, 1990; Ghafoor *et al*., 2001; Upadhyaya *et al*., 2002; Upadhyaya, 2003). Genetic diversity analysis reveals, genetic backgrounds and relationships of unitize and manage crop core collections (Brown-Guedira *et al*., 2000). Soybean genetic diversity and relationships can be studied by various morphological and agronomic traits, pedigree information, geographic origins, isozymes and DNA markers (Dong *et al*., 2004, Guan *et al*., 2010, Wang *et al*., 2010). In a study 49 local soybean varieties from Yunnan province in China were evaluated using principal component analysis (PCA) and hierarchical cluster analysis (HCA). The results showed that 4 Eigenvalues of PCA explained 88.34% of total variance. Also the HCA, showed, there were 5 clusters that some of them had suitable condition for parents materials selection (Zhao *et al*., 2007). On the other study 19 soybean genotypes were evaluated under two drought stress and non-stress conditions. The result of factor analysis in drought stress condition showed 5 independent factors for characters to explain 78.018 percent of total variation. A similarity factor analysis was conducted using nearest neighbor method for morphological characters of varieties and they were classified into 7 groups. The results of the cluster analysis revealed that TNH_{56} and BP genotypes were suitable for cultivation under drought stress condition (Salimi *et al*., 2012). Narjesi *et al*, (2007) reported that 5 independent factors for characters of 30 soybean genotypes can explain 80.2 percent of total variation. Based on the results 22.54% of total variation was explained by first factor and it was named the phonological properties. A study was conducted on 170 soybean genotypes under Soil salinity in nine morpho-physiological characters on 30-days-old seedlings plants. The first and second components of principal component analysis (PCA) explained 97% and 2.5% of the total variations of soybean genotypes, respectively. There were four clusters distinguished in the cluster analysis (Manna *et al*., 2010). In the other study 91 soybean landraces from Shaanxi province, of China, were evaluated using simple sequence repeat (SSR) markers and agronomic traits. UPGMA cluster analysis and PCA analysis clearly showed that, 91 mentioned accessions were formed in two major clusters which had generally correspond to them geographic origins (Liu *et al*., 2011). In a research, 364 soybean genotypes were studied based on cluster analysis and classified in three groups for yield and its components (Masoudi *et al*., 2008). The objectives of this study are evaluation genetic variation of soybean cultivars and grouping the studied traits using factor and cluster analysis to study and characterize population structure under drought stress and non-stress conditions.

Materials and methods

Experimental design and studied cultivars

This experiment was conducted in Mahidasht Agricultural Research Station located at 15 kilometers far from Kermanshah at the west of Iran as 46º, 26′ Eastern and 34º, 8′ Northern. The experiment design was RCBD with three replications in two normal and drought stress conditions. The soil of farm was tested and considering necessary micro and macro elements, the manures consumed. In present study 14 soybean cultivars were evaluated including Baj-Maj, M_9, Hy-1, L_{17}, Union, Bonus, Williams, Hack, Clark, Halcor, Flanklin, LD_9, Steel and Elgine from II and III maturity groups. The drought stress was induced as interval irrigation 7 versus 14 days from flowering stage. The method was basin irrigation using counter

and consumed water was 300 lit/plot in each irrigation stage, considering water essential of soybean (Panndy, 1987). Each plot was included four rows with four meters length and 50 cm row spacing and plant to plant space was 10 cm.

The studied traits

The eleven traits were recorded including: Growth duration as difference between emergence date and maturity date of plants in plots. Average leaf area as calculation of ratio surface of 20 dry leaves from 9 random plants to dry mass of total leaves of them. One hundred grain weight was measured, using seed counter and digital balance. The number of grains per plant, the number of pods per plant and inter nod by counting number of nods on main branch and divided to plant height. The number of sub branch, Plant height by measuring length of ultimate shoot to collar. The grain yield of whole plot was measured and converted to yield per hectare.

The used statistical analysis

The factor analysis using principal component analysis (PCA) and cluster and discriminant analysis were performed using $Spss_{16.0}$ soft wares.

Results and discussion

Cluster analysis on cultivars and categorizing traits under non-stress condition

The cluster analysis based on ward method and cutting dendrogram on 7 degree of Euclidean distance showed the cultivars were grouped by four clusters under non-stress condition (fig.1). The evaluation of dendrogram under non-stress condition, showed that the high yield cultivars as L_{17}, Union, Bonus, Williams, Steel, Elgine, Clark with about 600 to 680 Kg/ha were in the cluster number III. The cultivars such as M_9, Hy-1 and LD_9 with about 500 to 650 Kg/ha were in the cluster number II. The low yield cultivars such as Hack, Halcor and Flanklin with about 240 to 335 Kg/ha were in the cluster number IV. The Baj-maj cultivar with 408.22 Kg/ha were in the cluster number I respectively (fig.1, Tab.3). In factor analysis on 9 traits under non-stress condition, there were three components with 73.86% of variation after rotation with varimax method. The contributions of the first, second and third components were 38.08%, 20.56% and 15.21% respectively (Tab.4). Based on the most coefficients (PCA), the first component was named yield and plant structure. The second was named yield component and growth variables. The third was named yield components and growth time variables. In a study on 49 local soybean varieties from Yunnan province in China using PCA method, 4 components with 88.34% of cumulative variance proportion were acquired in evaluation of studied varieties (Zhao *et al.*, 2007). The result of a study was showed 5 independent factors for characters of 30 soybean genotypes could explain 80.2 percent of total variation (Narjesi *et al.*, 2007). The cluster analysis based on ward method and cutting dendrogram on 8.5 degree of Euclidean distance showed that studied traits were grouped by four clusters under non-stress condition (Fig.2). Considering coefficient correlations (Tab.1) and dendrogram (Fig.2), it was identified that due to grain yield per hectare had positive and significant correlation with plant height (0.778**) and inter nod (0.589**) and 100 grain weight (0.489**) so they were grouped in cluster number I. It seems, the taller plants with more inter nod due to high photosynthesis and large grains, had more grain yield so these traits were grouped in same cluster. Because the correlation between grain yield per hectare and average leaf area (0.307*) is lower so it was grouped in the other cluster (II). The positive and significant correlation between growth duration and number of grains per plant (0.352*) can be a reason for grouping them in the cluster number III although this correlation was low level. Considering positive and significant correlation between number of sub branch and number of pods per plant (0.604**), and grouping them in the cluster number IV., it was concluded under normal irrigation condition, with increasing sub branches, the generating buds were developed so that the number of pods per plant were increased and grouping them in same cluster (Fig. 2 and Tab.1).

Cluster analysis on cultivars and categorizing traits under stress condition

The cluster analysis based on ward method and cutting dendrogram on 7 degree of Euclidean distance showed that cultivars were grouped by three clusters under stress condition (Fig.3). Evaluation of denrogram, showed that The low yield cultivars such as Baj-maj, Steel, Williams, Bonus, Hack, Halcor and Flanklin with 220 to 330 Kg/ha were in the cluster number I. The cultivars as Hy-1, Elgine and M_9 with about 430 to 280 Kg/ha were in the cluster number II. On the other hand, the high yield cultivars as Clark, LD_9, L_{17} and Union with about 330 to 470 Kg/ha were in the cluster number III. (Fig.3). Salimi *et al.,* (2012) reported that TNH_{56} and BP genotypes were suitable for sown in drought stress condition using cluster analysis. Factor analysis on 9 traits under stress condition showed that, there were three components with 74.79% of traits variation with rotation varimax method. The contribution of first, second and third components were 32.57%, 27.20 and 15.02 respectively. Based on the most coefficients (PCA), the first was named component of yield. The second was named growth variables and yield. The third was named branch and yield of component (Tab.6). In a study, the result of factor analysis in drought stress condition showed that 5 independent factors for characters to explain 78.018 percent of total variation (Salimi *et al.*, 2012). The cluster analysis based on ward method and cutting dendrogram in 12.5 degree of Euclidean distance showed studied traits were grouped by four clusters under stress condition (Fig.4). Considering coefficient correlations (Tab.2) and dendrogram (Fig.4), it was identified due to number of pods per plant had positive and significant correlation with number of grains per plant (0.844**), Plant height with number of grains per plant (0.676**) and inter nod (0.736**) and number of pod per plant (0.637**) and so correlation between inter nod with number of grains per plant (0.581**) and number of pods per plant (0.448**)., they were grouped in the cluster number I (Fig.4). It's seems although existence drought stress condition, the taller plants with more length inter nod had larger grains and more pods so they were grouped in same cluster. The growth duration and yield of grain per hectare due to positive and significant correlation (0.624**) were grouped in the cluster number II. The two traits including average leaf area and one hundred grain weight with positive significant correlation (0.447**) were in the cluster number III. Due to there was not any correlation between the numbers of sub branch with any traits, it was grouped in a separate cluster.

Discriminate function on studied cultivars under non-stress condition

The evaluation of discriminate function on 14 soybean cultivars under non-stress condition showed, 3 functions with eigenvalues more than 1 explained 100% of total cultivar variations. The contribution of first function was 82.0% while second, third were 14.0% and 4.0% respectively (Tab.7). Considering (Tab.8) inter node, average leaf area and yield pre hectare had the highest standardized functional coefficients (3.230, 2.703 and 2.494) with first function; On the other hand, the highest coefficients with second function belonged to the number of pods pre plant and growth duration (1.016 and 0.839); In the third function, this coefficient was on yield pre hectare (1.321); It is concluded the mentioned traits in first function had the highest variation on studied cultivars because this function had the most contribution (82%) in explaining cultivars variation. Display all-groups scatter plot based on 1 and 2 functions showed that the group centre of 3 was in positive areas at both functions 1 (5.416) and 2 (1.257) (Tab.11 and Fig.5); It means, these cultivars have the highest variation because the contribution of functions 1 and 2 in explaining variation were (82.0%) and (14.0%) respectively. Considering functional coefficients of group centre of 2 in function 1 (-10.177) and function 2 (2.474) these cultivars have the lower variation than cultivars which in group of 3. Due to the center position of group centers of 1 and 4, in function 1 (-6.398), (-0.328) and function 2 (-3.716), (-4.170); it is concluded that these cultivars

have the lowest variation than others (Tab.11 and Fig.5).

Discriminate function on studied cultivars under stress condition

The evaluation of discriminate function on 14 soybean cultivars under stress condition showed 2 functions with eigenvalues more than 1 explained totally 100% of cultivar variations on the studied traits. The contribution of first and second function was 89.7%, 10.3% respectively (Tab.12). Considering plant height (1.882), the sub branches (0.962), the number of grains pre plant (0.448), yield per hectare (0.399) had the highest standardized functional coefficients with first function (Tab.13); Due to the high contribution of first function, it is concluded mentioned traits had the highest variation in studied cultivars. On the other hand the highest standardized functional coefficients with second function belonged to the number of pods per plant (1.150), inter nod (1.031), growth duration (0.859) and sub branches (0.850) so these traits had considerable variation in studied cultivars but this variation was the less than mentioned traits in function 1 (Tab.13). Display all groups scatter plot based on functions 1 and 2 in stress condition showed the center of group 3 was in positive areas of function 1 (6.738) and 2 (1.078); This means, studied cultivars in group 3 have the highest variation because the portion of functions 1 and 2 in explaining variation were (89.7%) and (10.3%) respectively. Due to the center position of group 2, in function 1 (0.932) and function 2 (-3.048); it is concluded that these cultivars have the relative variation but the less than cultivars which in group 3. Considering functional coefficients of group 1 in function 1 (-4.250) and function 2 (0.690), its cultivars have the lowest variation than others, because the contribution of function 1 was (82.8%) and this group had negative correlation with it (Tab.16 and Fig.6).

Table 1. The simple correlation between traits under non-stress condition.

	Growth duration	Number of sub branch	Plant height	Inter nod	Number of pods per plant	Number of grains per plant	Average leaf area	One hundred grain weight
Number of sub branch	-0.376	-						
Plant height	0.195	-0.101	-					
inter nod	0.359*	-0.209	0.783**	-				
number of pod per plant	-0.168	0.604**	0.329*	0.189	-			
number of grain per plant	0.352*	0.250	0.455**	0.316*	0.510**	-		
Average leaf area	0.260	-0.104	0.138	0.121	-0.018	-0.196	-	
One hundred grain weight	0.351*	0.027	0.530**	0.652**	0.136	0.181	0.360*	-
yield grain per hectare	0.118	0.114	0.778**	0.589**	0.253	0.370*	0.307*	0.489**

Table 2. The simple correlation between studied traits under stress condition.

	Growth duration	number of sub branch	Plant height	inter nod	number of pod per plant	number of grain per plant	Average leaf area	One hundred grain weight
number of sub branch	0.085	-						
Plant height	0.386*	-0.103	-					
inter nod	0.222	-0.248	0.736**	-				
number of pod per plant	0.089	0.129	0.637**	0.448**	-			
number of grain per plant	0.236	-0.020	0.676**	0.581**	0.884**	-		
Average leaf area	0.238	-0.093	0.520**	0.387*	0.122	0.140	-	
One hundred grain weight	0.416**	0.172	0.433**	0.136	0.362*	0.213	0.447**	-
yield grain per hectare	0.624**	-0.134	0.667**	0.551**	0.333*	0.489**	0.418**	0.177

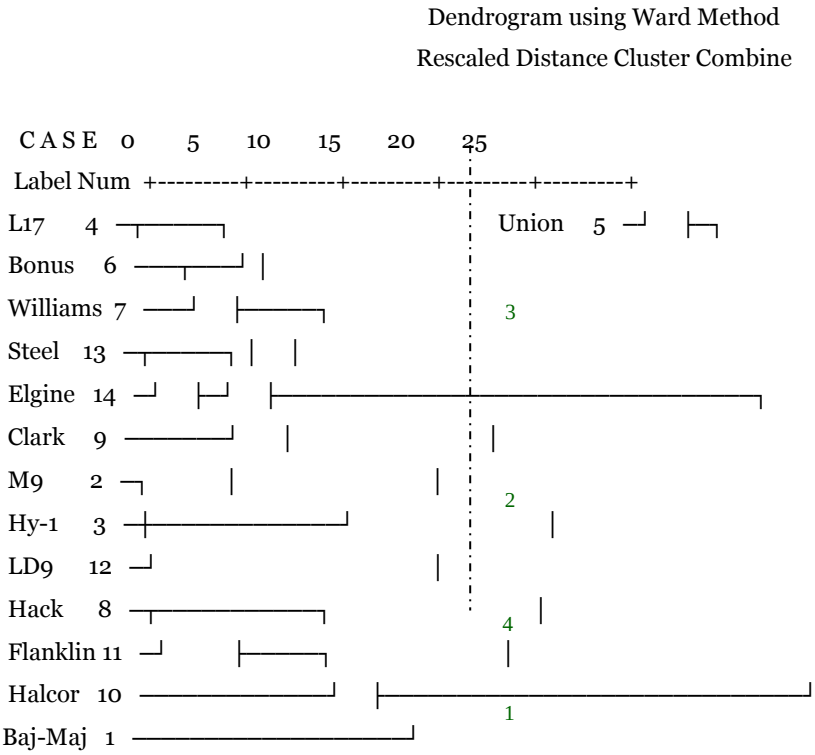

Fig. 1. Dendrogram of 14 soybean genotypes under non-stress condition using ward method.

Table 3. The acquired clusters of 14 soybean genotypes under non-stress condition with mean of cultivar traits.

		The mean of trait of clusters								
Cluster	**Cultivar**	**Growth duration**	**Number of sub branch**	**Plant height**	**Internod**	**Number of pod per plant**	**Number of grain per plant**	**Average leaf area**	**One hundred grain weight**	**yield grain per hectare**
I	Baj-Maj	107.0	6.3	15.68	1.673	47.32	100.20	12.75	78.17	408.2
	Hy-1	115.5	4.8	39.76	2.472	39.25	120.50	13.19	93.46	653.8
II	M9	111.7	4.5	40.85	2.693	50.77	117.20	13.28	84.62	531.8
	LD9	121.7	4.1	39.69	2.617	36.69	102.90	12.43	93.35	511.1
	L17	119.0	4.9	36.17	2.597	43.02	110.40	16.94	112.70	654.9
	Bonus	117.7	5.4	28.37	2.637	39.44	82.76	14.55	99.32	533.7
	Williams	124.7	4.3	25.27	2.477	37.93	96.24	16.59	97.46	337.6
III	Steel	112.5	4.1	31.77	2.282	37.22	81.10	16.92	86.47	594.4
	Clark	119.5	3.7	35.19	2.800	17.11	99.38	13.62	96.30	680.8
	Elgine	122.0	3.8	32.05	2.330	30.38	84.44	17.75	87.94	668.8
	union	117.5	4.5	42.25	2.840	35.58	94.22	17.71	104.70	684.2
	Flanklin	111.0	3.6	19.73	2.143	19.40	57.82	12.97	88.56	247.8
IV	Hack	109.3	4.5	18.79	1.790	20.23	67.47	15.28	80.08	330.1
	Halcor	128.0	3.8	19.99	2.070	24.46	115.00	14.11	81.99	336.3

Table 4. Factor analysis based on principal compone.

	Component		
	1	**2**	**3**
Eigenvalues	3.427	1.851	1.370
Cumulative %	38.080	58.644	73.863
Growth duration	0.099	**-0.382**	**0.220**
Number of sub branch	0.000	**0.489**	-0.044
Plant height	**0.,248**	-0.005	0.076
Inter nod	**0.239**	-0.122	0.075
Number of pod per plant	0.089	**0.378**	0.127
Number of grain per plant	0.086	-0.008	**0.536**
Average leaf area	0.172	0.087	**-0.596**
One hundred grain weight	**0.246**	0.013	-0.206
Yield per hectare	**0.253**	0.125	-0.127

nt method on traits under non-stress condition.

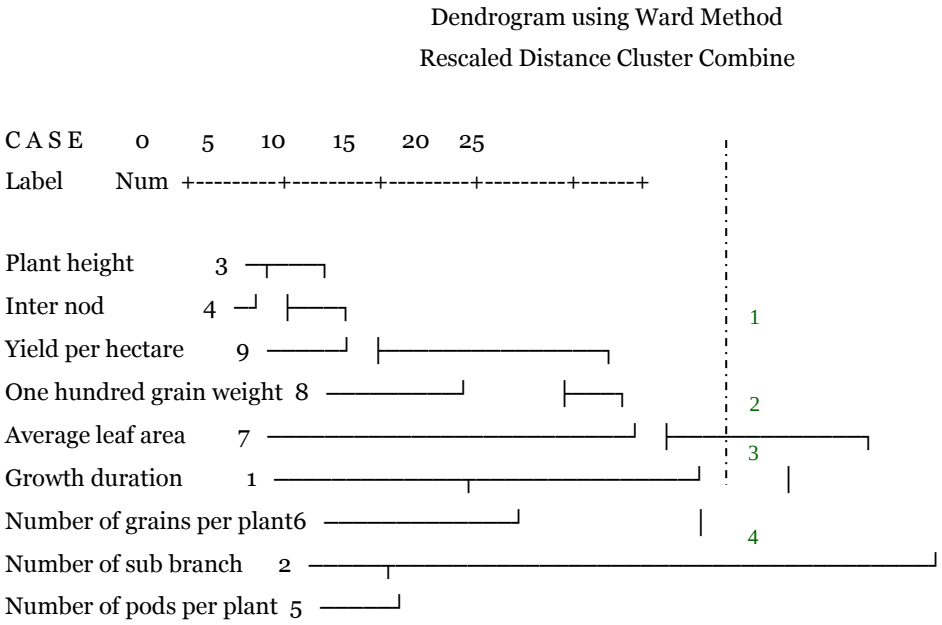

Fig 2. Dendrogram of 9 traits of soybean genotypes under non-stress condition using ward method.

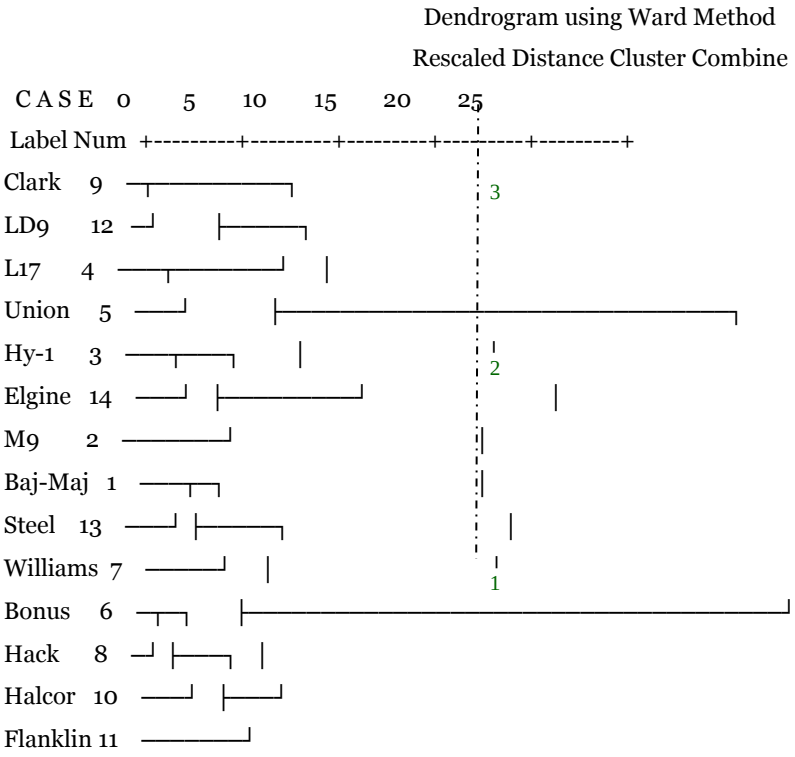

Fig. 3. Dendrogram of 14 soybean genotypes under drought stress condition using ward method.

Table 5. The acquired clusters of 14 soybean genotypes under drought stress condition with mean of cultivar traits.

The mean of trait of clusters										
Cluster	**Cultivars**	**Growth duration**	**Number of sub branch**	**Plant height**	**Inter nod**	**Number of pod per plant**	**Number of grain per plant**	**Average leaf area**	**One hundred grain weight**	**Yield per hectare**
I	Baj-Maj	116.6	3.9	20.93	2.16	24.52	49.33	12.11	70.14	225.2
	Steel	106.5	4.5	23.04	2.20	21.61	42.00	17.13	72.21	241.5
	Williams	119.7	4.4	19.15	2.06	12.78	38.94	16.31	71.27	331.2
	Bonus	117.5	5.3	16.70	2.00	27.60	56.85	13.03	73.00	330.7
	Hack	114.0	4.8	17.14	1.91	21.79	51.83	13.36	76.27	293.5
	Halcor	117.2	5.4	19.59	2.13	24.95	63.16	10.64	64.70	241.3
	Flanklin	107.5	5.5	16.06	1.82	19.00	40.29	12.91	59.33	277.7
II	M9	106.7	4.4	20.96	2.46	37.23	86.08	13.34	68.00	288.1
	Elgine	119.0	3.6	28.47	2.34	21.00	77.63	14.94	62.41	428.6
	Hy-1	117.5	4.6	26.67	2.19	33.40	73.88	13.35	69.39	399.8
III	union	121.0	5.4	29.63	2.25	25.36	56.46	15.73	80.81	331.8
	L17	119.0	5.1	31.74	1.98	38.19	75.63	16.48	83.70	345.7
	LD9	119.0	4.7	34.22	2.69	36.94	82.73	18.05	73.98	425.5
	Clark	119.7	4.8	35.42	2.77	31.49	75.38	16.66	76.62	474.6

Table 6. Factor analysis based on principal component method on traits under drought stress condition.

	Component		
	1	**2**	**3**
Eigenvalues	2.391	2.448	1.352
Cumulative %	32.572	59.772	74.797
Growth duration	-0.145	**0.398**	0.117
Number of sub branch	0.044	0.005	**0.638**
Plant height	0.183	0.131	-0.070
Inter nod	0.190	0.029	**-0.298**
Number of pod per plant	**0.417**	-0.192	**0.213**
Number of grain per plant	**0.396**	0.161	0.046
Average leaf area	-0.137	**0.367**	-0.093
One hundred grain weight	-0.047	**0.307**	**0.380**
Yield per hectare	0.021	**0.251**	-0.180

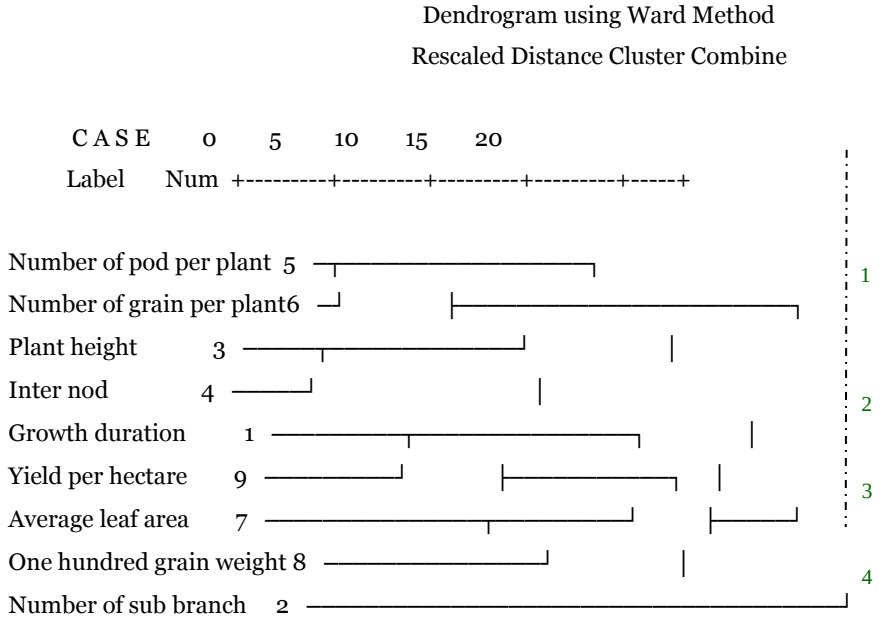

Fig. 4. Dendrogram of 9 traits of soybean genotypes under drought stress using ward method.

Table 7. Eigenvalue and cumulative percents of 3 canonical discriminant functions on 14 soybean cultivars under non-stress condition.

Function	Eigen value	% of Variance	Cumulative %	Canonical Correlation
1	55.734[a]	82.0	82.0	.991
2	9.540[a]	14.0	96.0	.951
3	2.713[a]	4.0	100.0	.855

Table 8. standardized canonical discriminant function Coefficients on 14 soybean cultivars under non-stress condition.

	Function		
	1	2	3
Growth duration	-.675	.839	-.066
Sub branches	-.805	-.113	.195
Plant height	-4.572	.542	-1.161
Inter nod	3.230	.489	.241
Number of pod per plant	-.364	1.016	.824
Number of grain per plant	-.241	-.835	-.115
Average leaf area	2.703	-.227	-.247
One hundred grain weight	.689	-.273	-.038
Yield per hectare	2.494	.639	1.321

Table 9. Canonical Discriminant Function Coefficients on 14 soybean cultivars under non-stress condition.

	Function		
	1	2	3
Growth duration	-.114	.141	-.011
Sub branches	-1.441	-.203	.349
Plant height	-1.062	.126	-.270
Inter nod	16.688	2.528	1.244
Number of pod per plant	-.048	.135	.110
Number of grain per plant	-.015	-.051	-.007
Average leaf area	1.998	-.168	-.183
One hundred grain weight	.090	-.036	-.005
Yield per hectare	.024	.006	.013
(Constant)	-34.877	-22.671	-1.362

Unstandardized coefficients

Table 10. Classification Results[a] on 14 soybean cultivars under non-stress condition.

	Ward Method	Predicted Group Membership				Total
		1	2	3	4	
OriginalCount	1	1	0	0	0	1
	2	0	3	0	0	3
	3	0	0	7	0	7
	4	0	0	0	3	3
	1	100.0	.0	.0	.0	100.0
	2	.0	100.0	.0	.0	100.0
	3	.0	.0	100.0	.0	100.0
	4	.0	.0	.0	100.0	100.0

a. 100.0% of original grouped cases correctly classified.

Table 11. Functions at Group Centroids on 14 soybean cultivars under non-stress condition.

Ward Method	Function		
	1	2	3
1	-6.398	-3.716	4.390
2	-10.177	2.474	-.568
3	5.416	1.257	.245
4	-.328	-4.170	-1.468

Unstandardized canonical discriminant functions evaluated at group means

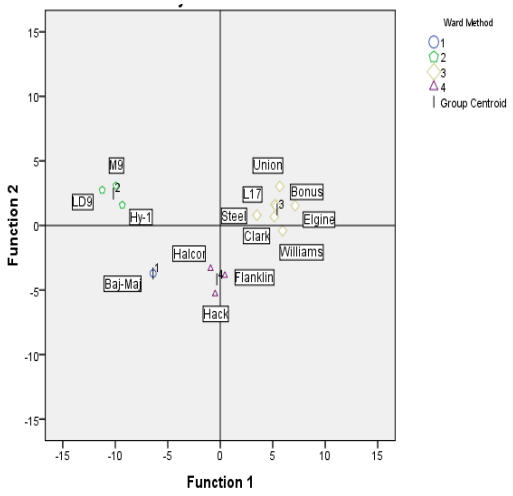

Fig. 5. Display all-groups scatter plot based on 1 and 2 canonical discriminant functions on 14 soybean cultivars under non-stress condition.

Table 12. Eigenvalue and cumulative percents of 2 canonical discriminant functions on 14 soybean cultivars under stress condition.

Function	Eigen-value	% of Variance	Cumu-lative %	Canonical Correlation
1	28.242[a]	89.7	89.7	.983
2	3.260[a]	10.3	100.0	.875

Table 13. Standardized Canonical Discriminant Function Coefficients on 14 soybean cultivars under stress condition.

	Function	
	1	2
Growth duration	-.124	.859
Number of sub branch	.962	.850
Plant height	1.882	-.192
Inter nod	-.872	1.031
Number of pod per plant	-.585	1.150
Number of grain per plant	.448	-1.591
Average leaf area	-.261	.483
One hundred grain weight	.441	.248
Yield per hectare	.399	-.667

Table 14. Canonical Discriminant Function Coefficients on 14 soybean cultivars under stress condition.

	Function	
	1	2
Growth duration	-.026	.180
Sub branches	1.863	1.647
Plant height	.808	-.083
Inter nod	-3.815	4.514
Number of pod per plant	-.099	.194
Number of grain per plant	.044	-.157
Average leaf area	-.144	.266
One hundred grain weight	.088	.049
Yield per hectare	.007	-.012
(Constant)	-23.873	-35.699

Unstandardized coefficients

Table 15. Classification Results[a] on 14 soybean cultivars under stress condition.

		Ward Method	Predicted Group Membership			Total
			1	2	3	
Original	Count	1	7	0	0	7
		2	0	3	0	3
		3	0	0	4	4
	%	1	100.0	.0	.0	100.0
		2	.0	100.0	.0	100.0
		3	.0	.0	100.0	100.0

a. 100.0% of original grouped cases correctly classified.

Table 16. Functions at Group Centroids on 14 soybean cultivars under stress condition.

Ward Method	Function	
	1	2
1	-4.250	.690
2	.932	-3.048
3	6.738	1.078

Unstandardized canonical discriminant functions evaluated at group means

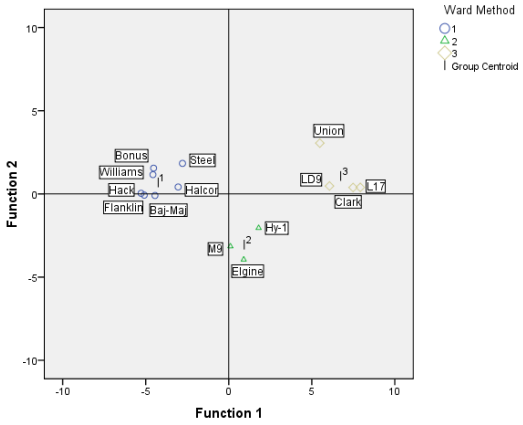

Fig. 6. Display all groups scatter plot based on 1 and 2 canonical discriminant functions on 14 soybean cultivar under stress condition.

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