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IDENTIFICATION OF ELITE LINES FOR SYNCHRONOUS PODS MATURITY THROUGH SCREENING OF LOCAL AND EXOTIC MUNGBEAN [*Vigna radiata* (L.) Wilczek] GENOTYPES

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Indeterminate plant growth and non- synchronous maturation of pods are the major obstacles towards harvesting of mungbean crop in one sitting. In order to identify elite mungbean genotypes for synchronous pods maturity and plant growth related traits, a principal component analysis was used. Fifty local and exotic mungbean genotypes were used for the purpose. The first four PCs with Eigen value >1 contributed 99.77% of the variability among the genotypes. The contribution of PC 1 towards total divergence was 53.47%. The studied traits contributed negatively to PC 1 except seed yield per plant. Days to 90% pods maturity and plant height at 90% pods maturity contributed significantly negatively towards the mentioned component. Therefore PC 1 could be attributed to plant maturity related traits. Plant height at first flower initiation has a positive weight on PC 2 while days to first pod maturity has a significant negative influence on it. The said PC is more related to plant flowering traits. Cluster analysis and class profile studies revealed the distinctiveness of variety AZRI-2006 and NM-2006. The said varieties showed lower estimates for most of the studied traits while the genotype 97006 and AUM- 9 have demonstrated the contrasting features especially for degree of indetermination of pod maturity and plant height.

Keywords: Degree of indetermination, pod maturity, plant height, cluster analysis, mungbean.

INTRODUCTION

Among food grain legumes, greengram enjoy a unique status, courtesy of its quality proteins. It thrives best in water limited conditions and is susceptible to water logging (Singh and Singh, 2011), requires a warm temperature of 30 to 35°C. Mungbean seed contains high quality proteins, amino acids, oligosaccharides and polyphenols, therefore it could be used as anti-oxidant, anti-microbial, anti-inflammatory and anti-tumor agent (Kanatt *et al*., 2011; Anjum *et al*., 2011). In Pakistan grain legumes are given secondary importance in comparison to cereal crops due to their lower yield and less responsive to inputs. Low yield in mungbean could be attributed to non-synchronous maturation of pods, indeterminate plant growth, lodging, low pod setting and tall bushy growth with shattering of pod and losses due to biotic and abiotic stresses (Chotechuen, 1996). As autumn (kharif) is the main greengram growing season in the country and plenty of rains (monsoon season) and consequently presence of higher soil moisture during plant reproductive phase **e**ven may contribute to the formation of multiple flower flushes in mungbean. Under subtropical conditions, non synchronous flowering could be due to the negative influence of long photoperiod on partitioning. Less photoperiod sensitive pigeonpea genotypes selected from temperate conditions showed synchrony in pods maturation with higher harvest index under tropical conditions. Initiation of flowering in greengram could be due to genetic, environmental and photothermal factors. Similarly indeterminate or twining growth habit is also an obstacle towards mechanical harvesting of the crop and affects the seed yield due to source/sink imbalance with prolongation of the maturity duration. Therefore maximum vegetative growth prior to reproductive phase and minimum increase after that is desirable (Tickoo *et al*., 1996) in order to produce determinate type of mungbean genotypes with maximum seed yield at first harvest. Uniform conversion from vegetative to reproductive phase is important for achieving synchronous pods maturity (Corbesier *et al*., 2003). For measuring the same, the estimate of degree of indetermination of growth duration is important (Khattak *et al*., 2004). A minimum degree of indetermination of pod maturity (DDd) and plant height (DDh) could help in curtailing the twining growth and achieving synchrony in pods maturity. Therefore for developing synchronous maturing, determinate type and high yielding mungbean genotypes, the preliminary breeding objective could be the categorization of mungbean genotypes. For the purpose principal component, an algorithmic statistical approach maybe used, as it is an effective technique of grouping/ classification of germplasm (Mohammadi and Prasanna, 2003) based on studied traits. Keeping in consideration this aspect, present research study was planned to identify elite mungbean genotypes for synchronous pods maturity and growth habit related traits through degrees of indeterminations.

MATERIALS AND METHODS

Fifty exotic and local mungbean genotypes of diverse genetic background were collected from various national research institutes (Table 1). The present research studies were conducted at the experimental field of Department of Plant Breeding Genetics, University of Agriculture Faisalabad, Pakistan during Autumn-2009. Mostly hot and humid weather conditions prevailed during the crop season (July- October- 2009) in Faisalabad. Higher evapotranspiration (ET_0) was recorded due to less cloudiness (Table 2). A randomized complete block design (RCBD) was followed with three replications. Each genotype was planted in a single row of 5 m length by maintaining a row and plant spacing of 30 cm and 10 cm, respectively. Recommended cultural/agronomic and plant protective measures were adopted. Ten guarded and consecutive plants from each row were selected for recoding the following data;

***Days to first flower initiation (D1)*:**Counted the days from date of planting to the appearance of first flower

***Days to first pod maturity (D2)*:** Counted the days from date of planting to the maturation of first pod

***Days to 90% pods maturity (D3)*:**Counted the days from date of planting to the maturation of 90% pods

***Plant height at first flower initiation (H1)*:**At first flower initiation plant height was measured with the help of meter rod from the base of the plant to the top most peduncle in cm.

***Plant height at first pod maturity (H2)*:**At first pod maturation plant height was measured with the help of meter rod from the base of the plant to the top most peduncle in cm.

***Plant height at 90% pods maturity (H3)*:**At 90% pods maturation plant height was measured with the help of meter rod from the base of the plant to the top most peduncle in cm. Further calculations were made according to the formulae outlined by Khattak *et al*. (2002, 2004).

***Degree of indetermination (DD) of pod maturity (DDd) from first pod maturity to 90% pods maturity*:**

$$DDd_2 = D3 – D2/D3 \times 100$$

***Degree of indetermination (DD) of plant height (DDh) from first flower to 90% pods maturity*:**

$$DDh_2 = H3 – H1/H3 \times 100$$

***Seed yield per plant*:**The same is weighted in grams using electronic balance OHAUS-AP310-0.

Analysis of variance was performed according to Steel *et al*. (1997). Principal component analysis as designed by Godschalk and Timothy (1988) was carried out with eigen value >1.0 were chosen, as proposed by Jeffers (1967) and cluster analysis were used for analyzing the studied traits through computer generated softwares ‘Statistica’ V 8.1 and ‘SPSS’ V12.0 for windows. A dendrogram was constructed with Euclidian distance based on the estimates of two variables. Simultaneously the Euclidean linkage distance was used for clustering the genotypes into various groups.

RESULTS AND DISCUSSION

Analysis of variance for studied traits revealed a genetic variation (Table 3) in the material. Tabasum *et al.* (2010) and Hidayat *et al.* (2012) also reported the existence of genotypic variations for plant height and pod maturity related traits in mungbean. Maximum variance (Table 3) was observed for the trait plant height at 90% pods maturity (36.43) followed by days to 90% pods maturity (28.62) and DDd_2 (27.84). Response of genotypes to various plant growth related traits was studied through principal component analysis approach.

***Principal component and cluster analyses*:**Nine traits, which were counted, measured, computed and analyzed using principal component analysis. Through principal component analysis contribution of various characters towards total divergence was computed. Those variables which contribute maximum to the variation hold greater significance. Eigen value of 06 principal components has been shown in the scree plots (Fig. 1). The first four components with eigen value more than one contributed

Table 1. Monthly weather conditions (average and long-term) at Faisalabad during crop period.

Month		Max. temp. (°C)	Min. temp. (°C)	Mean temp. (°C)	Relative humidity (%)	Total rainfall (mm)	ET_0 (mm)
July	Average	38.8	28.4	33.6	64.7	48.2	159.0
	Long-term	39.2	28.9	34.5	59.4	56.9	-
August	Average	36.6	27.6	32.2	65.8	116	152.3
	Long-term	37.7	27.9	32.8	58.1	80.4	-
September	Average	36.3	24.4	30.3	61.0	20.6	115.2
	Long-term	36.5	23.7	30.2	30.7	55.2	-
October	Average	32.7	17.1	24.9	57.9	17.5	96.90
	Long-term	32.1	18.3	25.2	57.2	5.92	-

Table 2. Mungbean genotypes used for screening trial along with their source.

Sr.#	Genotype	Source /Origin	Distinct features	Reference	Sr.No.	Genotype	Source /Origin	Distinct features	Reference
G1	07001	PRI,AARI, Faisalabad	-	-	G26	NM 121-25	NIAB, Faisalabad	Semi determinate, late maturity	Ashraf *et al*, (2001)
G2	07002	PRI,AARI, Faisalabad	-	-	G27	AUM-6375	UAF		
G3	07003	PRI,AARI, Faisalabad	-	-	G28	AUM-18	UAF	Medium maturity	Rehman *et al*., (2005)
G4	07005	PRI,AARI, Faisalabad	-	-	G29	M-2002	UAF	-	-
G5	07006	PRI,AARI, Faisalabad	-	-	G30	M-2006	UAF	-	-
G6	AZRI-2006	PRI,AARI, Faisalabad			G31	AUM-9	UAF	Medium maturity	Rehman *et al*. (2005)
G7	97002	PRI,AARI, Faisalabad	-	-	G32	AUM-31	UAF	Medium maturity	Rehman *et al*. (2005)
G8	97004	PRI,AARI, Faisalabad	-	-	G33	AUM-24	UAF	Medium maturity	Rehman *et al*. (2005)
G9	97006	PRI,AARI, Faisalabad	Medium maturity	Rehman *et al*. (2005)	G34	AUM-28	UAF	Medium maturity	Rehman *et al*. (2005)
G10	97012	PRI,AARI, Faisalabad	Medium maturity	Rehman *et al*. (2005)	G35	AUM-19	UAF	Medium maturity	Rehman *et al*. (2005)
G11	97017	PRI,AARI, Faisalabad	Medium maturity	Rehman *et al*. (2005)	G36	AUM-38	UAF	Medium maturity	Rehman *et al*. (2005)
G12	98001	PRI,AARI, Faisalabad	-	-	G37	AUM-27	UAF	Medium maturity	Rehman *et al*. (2005)
G13	98002	PRI,AARI, Faisalabad	-	-	G38	M-2004	UAF	-	-
G14	98005	PRI,AARI, Faisalabad	-	-	G39	SM-1	ARS	-	-
G15	98009	PRI,AARI, Faisalabad	-	-	G40	VC-1482	NIAB/AVRDC	Semi determinate, early maturity	Ashraf *et al*. (2001)
G16	NM-2006	NIAB, Faisalabad	Determinate, synchronous and early pods maturity	Sadiq *et al*. (2006)	G41	VC-1560	NIAB/AVRDC	Semi determinate, early maturity	Khattak *et al*. (2002)
G17	NM 13-1	NIAB, Faisalabad	-	-	G42	VC-1628	NIAB/AVRDC	Semi determinate, early maturity	Ashraf *et al*. (2001)
G18	NM 92	NIAB, Faisalabad	Semi determinate, early maturity	Khattak *et al*. (2002)	G43	VC-2754	NIAB/AVRDC	Semi determinate, early maturity	Ashraf *et al*. (2001)
G19	NM 20-21	NIAB, Faisalabad	Semi determinate, medium maturity	Ali *et al*. (1997)	G44	VC-2771	NIAB/AVRDC	Semi determinate, late maturity	Khattak *et al*. (2002)
G20	NM 98	NIAB, Faisalabad	Semi determinate, late maturity	Khattak *et al*. (2002)	G45	VC-2778	NIAB/AVRDC	Semi determinate, early maturity	Ashraf *et al*. (2001)
G21	NM 19-19	NIAB, Faisalabad	Semi determinate, medium maturity	Ali *et al*. (1997)	G46	VC-2984B	NIAB/AVRDC	-	-
G22	NM- 54	NIAB, Faisalabad	Semi determinate, early maturity	Ashraf *et al*. (2001)	G47	VC-3476	NIAB/AVRDC	-	-
G23	Var-6601	NIAB, Faisalabad	indeterminate, late maturity	Khattak *et al*. (2002)	G48	VC-3902	NIAB/AVRDC	Semi determinate, medium maturity	Khattak *et al*. (2002)
G24	NM-28	NIAB, Faisalabad			G49	VC-3960	NIAB/AVRDC	-	-
G25	NM-51	NIAB, Faisalabad	Semi determinate, medium maturity	Khattak *et al*. (2002)	G50	VC-6369	NIAB/AVRDC	-	-

RRI, Fsd. = Pulses Research Institute, Faisalabad, UAF = University of Agriculture, Faisalabad, NIAB, Fsd. = Nuclear Institute of Agriculture and Biology Faisalabad, ARS = Agricultural Research Station, Mingora, KPK, NIAB/AVRDC = NIAB, Faisalabad/Asian Vegetable & Research Development Centre, Taiwan

Table 3. Basic statistics for nine different plant growth related traits in mungbean.

Character	D.F.	Mean Squares	Mean	Min. value	Max. value	Std. Dev.	Variance
Days to first flower initiation	49	12.72**	33.98	29.65	37.45	2.14	5.94
Days to first pod maturity	49	32.51**	47.66	43.67	55.00	2.50	6.26
Days to 90% pods maturity	49	109.70**	86.61	78.33	98.00	3.99	15.91
DDd_2	49	53.18**	44.82	32.15	55.44	4.24	17.96
Plant height at first flower	49	17.05**	32.93	25.40	41.00	2.78	7.72
Plant height at first pod maturity	49	35.05**	42.95	33.57	51.74	7.89	49.84
Plant height at 90% pods maturity	49	84.77**	55.70	41.73	74.87	5.12	26.33
DDh_2	49	78.70**	40.39	24.91	58.11	7.20	51.90
Seed yield per plant (g)	49	16.15**	6.11	3.76	8.02	2.15	5.95

** = P<0.01

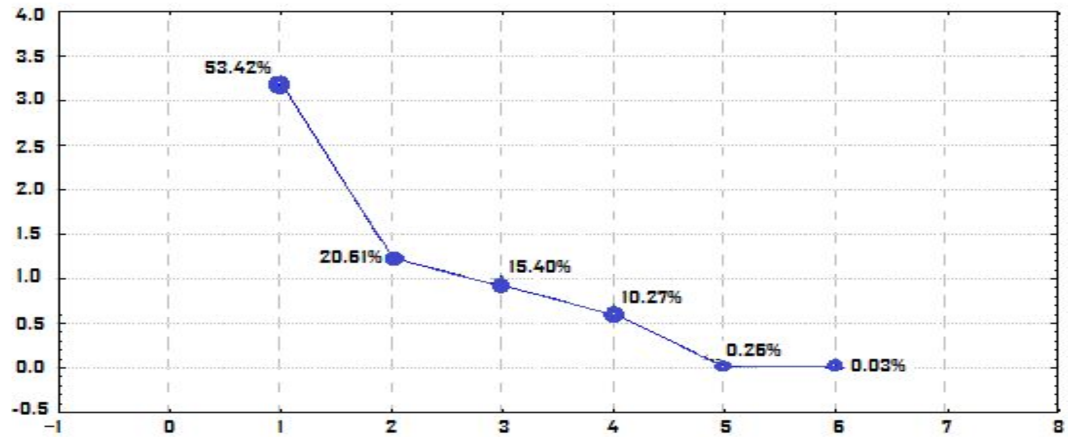

Figure 1. Scree plot constructed for 06 principal components in mungbean.

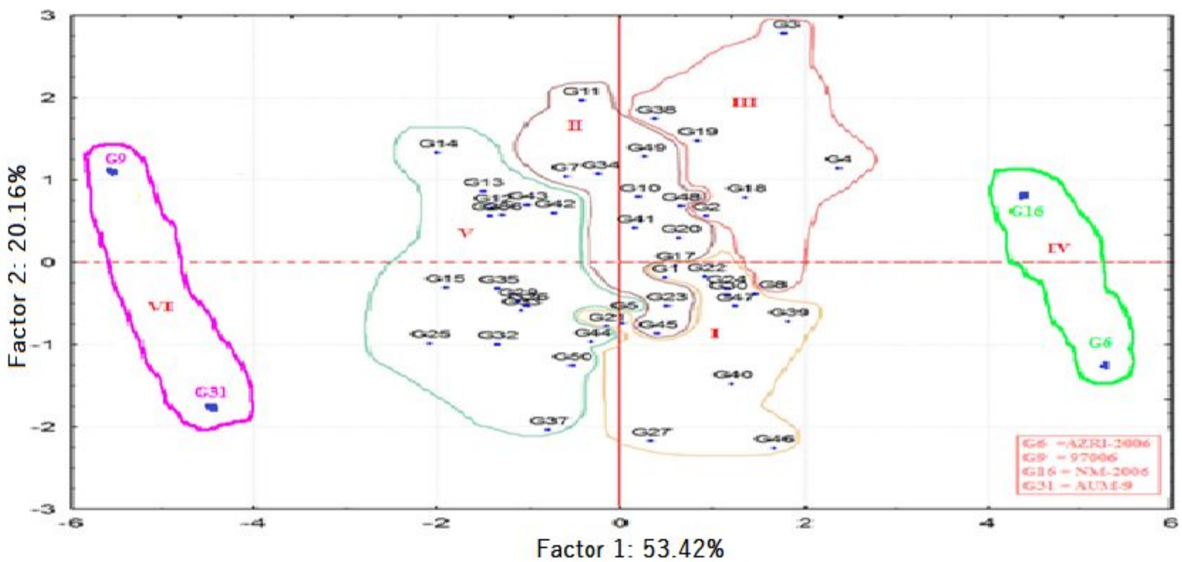

Figure 2. Scatter diagram of 50 mungbean genotypes on their principal component scores superimposed with clustering.

99.77 percent of the total variation. The last two components have eigen value less than 1. The contribution of first component was 53.42 percent. The traits with negative significance for PC1 were days to 90% pods maturity (-0.93) and plant height at 90% pods maturity (-0.94). Positive loadings indicate a variable and a principal component are positively correlated: an increase in one results in an increase in the other. Negative loadings indicate the reverse, a negative correlation. Hence in this case negative values indicate early maturity with dwarfness. The higher the coefficients, the more effective they will be in discriminating among the genotypes regardless of the direction (positive or negative). For the said component reducing effect of traits influence the seed yield positively. PC II (20.61%) and PC III (15.40%) also played prominent role in total variation (Fig. 1). The traits showing the most variation may be given greater importance while selecting the cluster for the choice of parents and for hybridization programme (Jagadev *et al.*, 1991). Clifford and Stephenson (1975) noticed that the first three principal components are often the most important one which indicate the variation patterns among genotypes and the characters associated with these are more useful in differentiating genotypes. Table 4, showed that all the traits contributed negatively to both the PCs (PC1 and PC2) except seed yield per plant (0.279 and 0.248, respectively) and plant height at first flower initiation (0.742) for PC 2 only. Days to 90% pods maturity (-0.930), DDd_2 (-0.835) and plant height at 90% pods maturity (-0.943) had a highest negative influence on PC 1, while day to first pod maturity (-0.720) on PC2. Nawab *et al.* (2013) and Toker (2004) also noticed negative values for days to first flowering and plant height for PC1 in chickpea. The negative values of factor loadings for different traits imitate the importance of early reproductive phase which tend to minimize DDd_2 and increase the seed yield per plant. Days to first flower, first pod maturity and DDd_2 had a significant importance for synchronous maturation of pod in mungbean (Tah and Saxena., 2009). From the results it was concluded that dwarfness at the inception of reproductive phase could help to reduce twinning growth (DDh_2) and at the same time could improve the seed yield in greengram. In field pea, significant improvement in seed yield (30%) was made by developing dwarf type plants (Nadarajan and Gupta, 2010).

Table 4. Coefficients vectors and correlation matrix with the first two principal components.

	PC I	PC II
Eigen value	3.18	1.61
% Total – variance	53.42	20.61
Cumulative - %	53.85	79.93
Characters Co-efficient vector		
Days to first flower initiation	-0.084	-0.056
Days to first pod maturity	-0.297	-0.720
Days to 90% pods maturity	-0.930	-0.150
DDd_2	-0.835	-0.402
Plant height at first flower initiation	-0.465	0.742
Plant height at first pod maturity	-0.048	-0.053
Plant height at 90% pods maturity	-0.943	-0.067
DDh_2	-0.660	-0.592
Seed yield per plant	0.279	0.248

A two-dimensional scatter diagram was constructed using components I and II as the axes (Fig. 2). The genotypes were apparently distributed into six clusters. Maximum (18) genotypes were noticed in cluster V, followed by 11, 10 and 7 in clusters II, I and III, respectively. Two genotypes each were there in cluster IV and VI. The genotypes of cluster I, II, III and V were nearly intermingled. However cluster IV and VI were clearly separated from the rest. The said clusters had two genotypes each. The availability of few genotypes in these clusters was perhaps due to limited number of studied characters and their duplication effect. Only four genotypes had shown variation for the studied traits and the rest of the 46 genotypes behaved nearly in a similar manner. As the said study was particularly focused on the plant growth habit related traits and additionally non-synchronous maturation of pods and indeterminate increase in plant height is a natural phenomenon in mungbean crop (Tickoo *et al*., 1996). The same was witnessed in the studied genotypes; therefore most of the mungbean genotypes clustered themselves in close proximity. In contrary only planned breeding efforts could generate synchronous maturing and determinate type genotypes. But before initiating this sort of breeding studies, multi-locational screening trials comprised of extensive local and exotic mungbean genetic stock must be conducted during both crop seasons in Pakistan. Huidong and Shilian (1987) also urged the utilization of maximum genotypes for conducting screening trials. However, in present case, only two cultivars (AZRI-2006 and NM-2006) out of fifty studied mungbean genotypes remained determinate/semi-determinate (minimum increase in plant height after the onset of reproductive phase) with minimum degree of indetermination of pods maturity (synchronous maturation of pods). Few exotic genotypes were also used in this investigation (Table 2). It is inferred from the results that local and exotic genotypes used in the study have the tendency of indeterminate growth and non synchronous maturation of pods except the two approved varieties (cluster IV). However introduction of exotic genotypes in Pakistan is problematic due to photoperiod sensitivity and susceptibility to MYMV. Saxena *et al*. (2005) exercised cluster analysis in order to classify the mungbean genotypes into various groups. Afroz *et al.* (2004) noticed six clusters in mustard. Cluster IV has the lowest mean values (38.3) for all the nine traits (Table 5). Two varieties (AZRI-2006 and NM-2006) belonged to said cluster (Fig.2). In contrary on an average maximum cluster mean (48.2) was observed for cluster VI (Table 5). Two genotypes (97006 and AUM-9)

Table 5. Clusters means for various characters in mungbean.

	C I	C II	CIII	C IV	C V	C VI	Mean
Days to first flower initiation	34.5	35.5	34.6	33.8	34.8	36.4	34.9
Days to first pod maturity	50.6	46.7	48.1	50.2	46.5	44.3	47.7
Days to 90% pods maturity	84.8	85.6	87.3	75.5	88.1	96.8	86.4
DDd_2	40.4	45.4	44.8	33.5	47.1	54.2	44.2
Plant height at first flower initiation	32.9	33.4	35.4	33.8	32	29.3	32.8
Plant height at first pod maturity	41.5	43.5	44.5	40.8	42.5	42.8	42.6
Plant height at 90% pods maturity	56.6	54.6	51.1	45.5	57.4	67.7	55.5
DDh_2	41.6	38.3	30.5	25.1	44.7	56.1	39.4
Seed yield per plant	4.28	4.30	3.98	6.75	4.75	5.91	5.0
Cluster Mean	43.0	43.0	42.3	38.3	44.3	48.2	

have occupied the said cluster. It has the maximum value for days to first flower initiation (36.4), days to 90% pods maturity (96.8), DDd_2 (54.2), plant height at 90% pods maturity (67.7) and DDh_2(56.1). For the investigation of gene action and related studies genetically distant parents may be picked and crossed. In the present study, the maximum distance occurred between cluster IV and VI (Fig.2). Therefore cross combinations between the genotypes of cluster IV (AZRI-2006 and NM-2006) with that of clusters VI (97006 and AUM-9) could help to bring maximum genes in the studied population which govern the inheritance of above mentioned traits. The use of multivariate analysis could be an effective approach for the classification of mungbean germplasm for particular traits and for measure of genetic relationships (Mohammadi and Prasanna, 2003). Rahim *et al*. (2008) studied 34 genotypes of greengram for 8 morphological characters and classified them into 7 clusters. Wheat genotypes were also effectively categorized into various clusters based on their morphological characters through cluster analysis technique (Fufa *et al*., 2005). By applying Wards algorithm and squared Euclidean distances of cluster analysis Aharizad *et al*. (2012) placed ninety four bread wheat genotypes into three groups.

A dendrogram (Fig. 3) was constructed based on two variables (DDd_2 and DDh_2) only. Fifty mungbean genotypes were placed into various small groups based on their average linkage distances. The minimum linkage distance between and among the genotypes specify their genetic similarity and relatedness. The same was witnessed between C I and C II. The genotypes of cluster V and VI showed maximum linkage distance from rest of the genotypes and the clusters. Approved variety AZRI-2006 and NM-2006 (cluster IV) revealed a linkage distance with the genotype 97006 and AUM-9 (cluster VI) for DDd_2 and DDh_2 traits. The same illustrated maximum heterogeneity between the said varieties and the genotypes. The exotic genotypes starting from VC-1482 to VC-6369 (Table 2) showed similarity with the local genotypes which is indicative of the universal existence of the phenomenon of indeterminate growth in mungbean.

Fifty genotypes were disseminated into four distinct classes

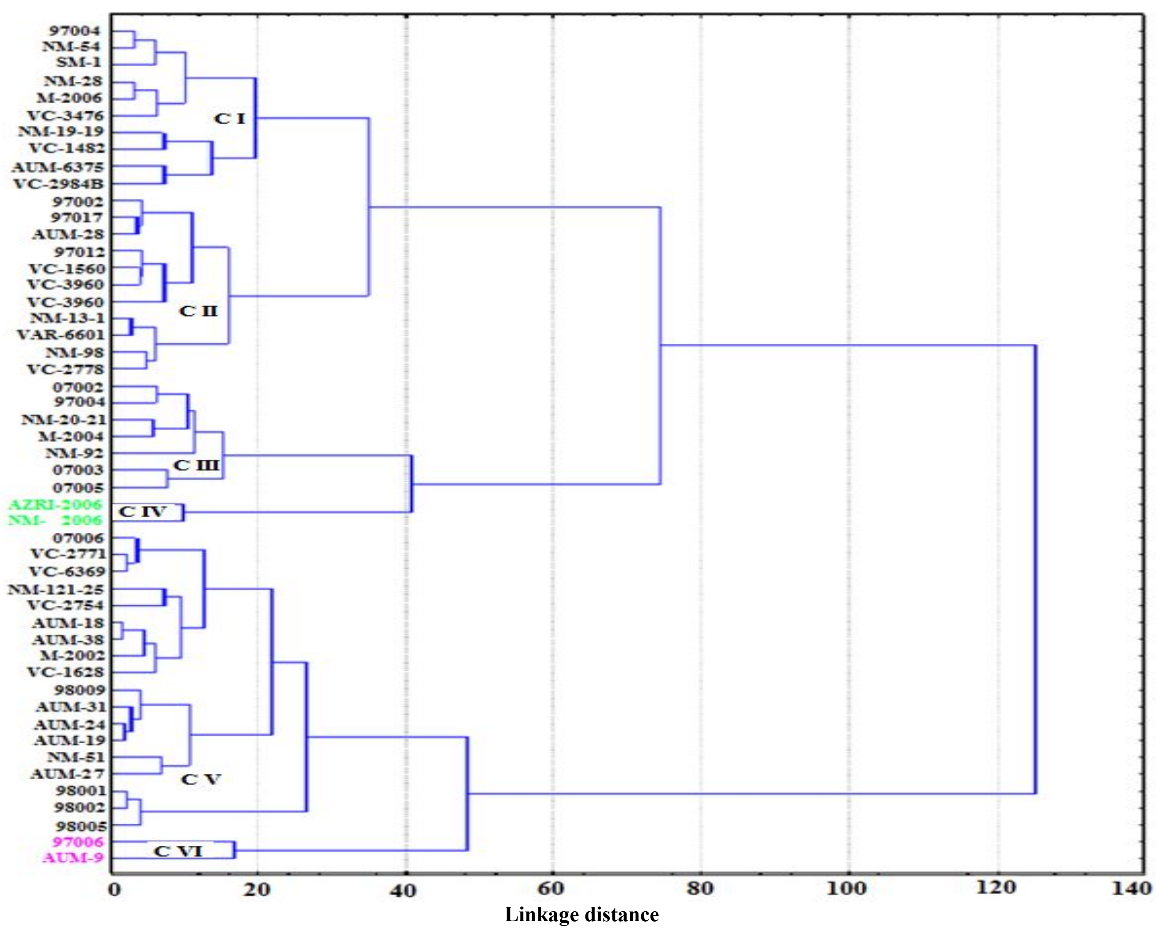

Figure 3. Dendrogram of 50 mungbean genotypes based on DDd_2 and DDh_2 traits.

Table 6. Distribution of 50 mungbean genotypes into 4 distinct classes based on mean values of DDd_2 and DDh_2 traits.

CLASS 1				CLASS 2				CLASS 3				CLASS 4			
Genotype	DDd_2	DDh_2	combined	Genotype	DDd_2	DDh_2	combined	Genotype	DDd_2	DDh_2	combined	Genotype	DDd_2	DDh_2	combined
AZRI-2006	30.7	29.1	59.8	NM 13-1	35.4	33.1	68.5	98001	41.7	39.4	81.1	7002	42.2	44.6	86.8
NM-2006	32.4	31.2	63.6	NM 92	36.7	33.7	70.4	98002	40.2	40.6	80.8	7005	43.5	43.4	86.9
				NM 98	37.5	30.4	67.9	M-2002	41.4	40.1	81.5	97002	42.6	44.5	87.1
				NM-28	37.2	36.4	73.6	AUM-28	40.6	39.7	80.3	97017	44.5	42.3	86.8
				NM-51	34.5	36.2	70.7	AUM-38	42.1	38.6	80.7	97006	58.1	55.4	113.5
				NM 121-25	38.5	35.1	73.6	VC-3960	39.7	40.4	80.1	98005	43.1	50.0	93.1
				07001	41.4	38.6	80	VC-6369	41.2	38.6	79.8	98009	48.0	48.7	96.7
				7006	40.1	39.4	79.5	7003	39.3	43.5	82.8	NM 19-19	47.3	41.7	89.0
				97004	36.4	40.2	76.6	NM 20-21	41.6	41.8	83.4	AUM-6375	45.4	40.8	86.2
				97012	39.4	37.6	77	M-2006	39.7	41.6	81.3	AUM-18	43.5	49.0	92.5
				NM- 54	39.5	38.6	78.1	VC-3902	37.6	44.1	81.7	AUM-9	51.2	52.4	103
				Var-6601	41.5	37.2	78.7	AUM-19	34.3	47.6	81.9	AUM-31	48.2	46.4	94.6
				M-2004	39.3	39.4	78.7	VC-1482	44.1	37.6	81.7	AUM-24	46.4	46.6	93.0
				VC-2754	40.6	38.6	79.2	VC-2778	41.3	43.3	84.6	AUM-27	46.3	43.1	89.4
				VC-2771	40.6	36.7	77.3					VC-1560	40.8	44.8	85.6
				VC-2984B	40.2	39.8	80					VC-1628	43.1	46.2	89.3
				SM-1	38.4	38.9	77.3					VC-3476	40.7	48.6	89.3
Average	31.55	30.15			36.05	33.4			40.95	40.0			42.85	44.0	

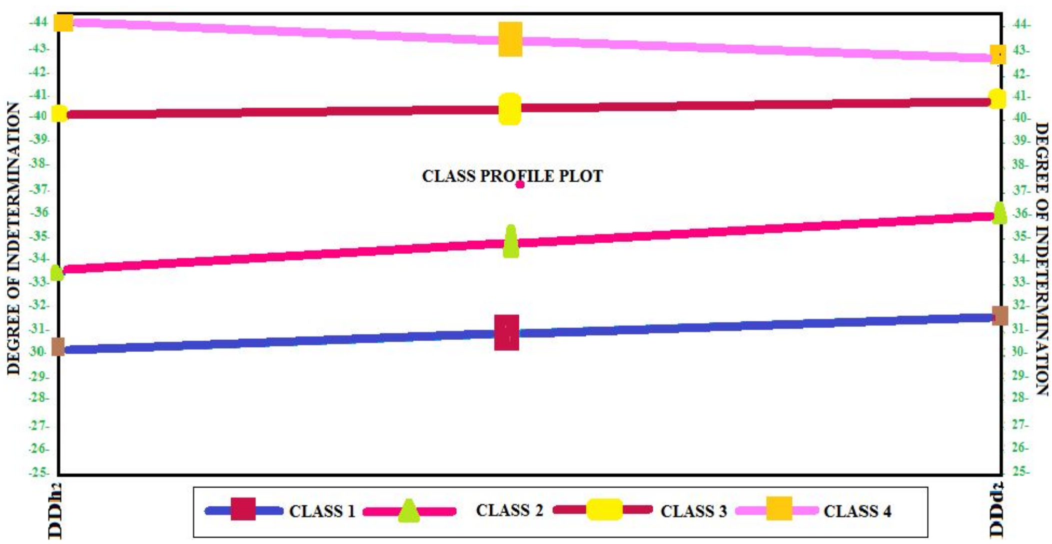

Figure 4. Class profile of 50 mungbean genotypes for two different traits.

(Table 6) based on the combined/cumulative estimates of DDd_2 and DDh_2 parameters. Two approved varieties (AZRI-2006 and NM-2006) belonged to class-1. Seventeen genotypes each fall in class-2 and 4 and the rest were attributed to class-3 (14). Class 1 has the lowest cumulative value of both degrees of indeterminations (61.70). Class 2 and 3 has the said estimates as 75.71 and 81.55, respectively. The highest cumulative degrees of indeterminations ($DDd_2$and DDh_2) were computed for class 4 (91.96). In a profile class plot (Fig. 4) class-4 has the highest DDh_2 value (44.0). As both the genotypes (97006 and AUM-9) with highest values of the said parameter (Table 6) belong to said class, while class-1has the lowest value (30.15) of the mentioned parameter. The difference might be due to the presence of AZRI-2006 and NM-2006 (varieties) in class-1, characterized by their determinate type of growth habit. Accordingly for the computed trait DDd_2; class- 1 showed minimum value (31.55) in comparison to other three classes (2, 3 and 4) with respective DDd_2 values as 36.05, 40.95 and 42.85. Variety AZRI-2006 and NM-2006 (class-1) remained distinct with lowest estimates of two degree of indeterminations (DDd_2 and DDh_2). While the highest for the same were observed for class-4 (Fig. 4) in which the genotype 97006 and AUM-9 were present. (97006 and AUM-9) (AZRI-2006 and NM-2006).

For developing a synchronous maturing and determinate type of mungbean, the genotypes with lower DDd_2 and DDh_2 value are preferred. A mungbean germplasm selection was carried out based on seed yield, DDd_2 and DDh_2 parameters (Table 7). Only two approved varieties (AZRI-2006 and NM-2006) had shown the worth in this regard. The same may be used in future breeding programme for the said purpose. In contrary for studying the gene action governing the inheritance of aforementioned traits inclusion of genotypes with higher DDd_2 and DDh_2 estimates is necessary. The same will not only help in pyramiding the genes in the experimental population but will also provide information regarding the nature and extent of such genes. Two genotypes (97006 and AUM-9) with mentioned features could serve the said purpose.

Table 7. Elite genotypes identified on the basis of important traits for future use.

Trait of interest	Trait value	Genotypes/varieties identified
DDd_2	Lowest value	AZRI-2006, NM-2006
	Highest value	97006, AUM-9
DDh_2	Lowest value	AZRI-2006, NM-2006
	Highest value	97006, AUM-9
Seed yield /plant	Highest value	AZRI-2006, NM-2006

***Conclusion*:**The investigated germplasm although had shown variation for the studied traits, however further analyses have revealed that the same is not enough to represent the two extremes of a trait; this urged the need to widen the scale/spectrum of mungbean germplasm collection and inclusion of further relevant parameters for this sort of studies. However this study was a preliminary effort, in connection with setting the criterion for the identification of elite mungbean genotypes and consequently for planning a work oriented breeding programme for developing synchronous maturing and determinate type mungbean lines in Pakistan and will certainly guide/facilitate future mungbean breeders in this regard.

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