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PHENOTYPIC DIVERGENCE FOR MORPHOLOGICAL, PHYSIOLOGICAL AND YIELD RELATED TRAITS AMONG SELECTED MUNGBEAN GENOTYPES UNDER DROUGHT STRESS AND NON STRESS CONDITIONS THROUGH CLUSTER ANALYSIS

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ABSTRACT

Thirty one mungbean genotypes were evaluated in summer under two conditions- non stress and water stress conditions. Data on fifteen agronomic and physiological traits are presented to assess the phenotypic diversity and to investigate the relationships between grain yield and other important yield components in mungbean. The coefficient of variation (CV) for all the genotypes ranges from 0.75% to 7.66% in non stressed environment and ranged from 0.61% to 14.56% in water stressed environment. Clustering based on mungbean genotypes separated the measured traits into four main groups under non stressed environment and also in stressed environment and based on traits it separated mungbean genotypes to two major groups in stressed conditions and three major groups in non stressed conditions. SCMR and Harvest index were the most related traits with grain yield per plant under stressed environment and Harvest index and chlorophyll content were the most associated traits with grain yield per plant under non stress environment. Therefore, it seems that for improving grain yield performance in non stressed conditions, genotypes COGG 974, IPM-02-19, RMG 492 and VG 6197A and in water stressed conditions, genotypes LGG 450, RMG 492, VG-6197A and WGG 37 are good candidates. Finally, for improving grain yield performance in both conditions, genotypes RMG 492 and VG-6197A can be used.

INTRODUCTION

Mungbean (*Vigna radiata* (L.) Wilczek) is an important pulse crop in India and occupies third rank after pigeon pea and chickpea. It is cheap and rich source of protein containing 23-25 per cent, high lysine content and rich in amino acids, minerals and vitamins. However, its production potential was reduced due to abiotic stress like drought. Many breeding programmes have been initiated to develop drought tolerant/ resistant varieties in mungbean.

The current demand to develop high yielding and drought tolerant genotypes necessitated an immediate need to breed suitable high yielding varieties under drought conditions. In order to reach this goal, drought tolerance and high yield is essential to identify and concentrate on the important traits that could contribute to optimum yields under drought.

Cluster analysis could be used as a statistical tool to bring information about appropriate cause and effect relationship between yield and yield components. This technique of using Euclidean distance for clustering the genotypes and traits were validated already in mungbean by Basnet *et al.* (2014) based on quantitative parameters, Katiyar *et al.* (2009) and Singh *et al.* (2010) in Brassica it was validated by Binodh *et al.* (2013) and in Pigeon pea it was validated by Yogendra *et al.* (2013). Grain yield is the primary factor affecting the economical value in mungbean and breeding efforts in increasing seed yield are being conducted. For effective selection, information on nature and magnitude of variation in plant materials, association of different traits with grain yield and among themselves is necessary. Fifteen agronomic and physiological traits were considered in this investigation to assess the distinctiveness and the level of phenotypic variation. The paper deals with identification of genotypes as possible sources of parental materials and also identification of traits which may be useful in breeding higher-yielding genotypes in non-stressed and water-stressed environments.

MATERIALS AND METHODS

The experimental material for the present investigation consisted of thirty one mungbean genotypes obtained from Regional Agricultural Research Station, Lam, Guntur and Agricultural Research Station, Madira. The experiment was conducted in randomized block design (RBD) with three replications during summer, 2013-14 at wet land farm, Sri Venkateswara Agricultural College, Tirupati. Each genotype was sown in three rows of 4 m length with a spacing of 30 cm between rows and 10 cms between plants within rows. In the present study, moisture stress was induced during pod filling stage by withholding irrigation for fifteen days and for control condition regular irrigation was given. Observations were recorded on five randomly selected plants per replication in both conditions for traits namely plant height, number of clusters per plant, number of pods per cluster, number of pods per plant, number of seeds per pod, 100 seed weight, harvest index, SPAD chlorophyll meter reading (SCMR), Relative Water Injury (RWC), Relative Injury Percentage (RI), Chlorophyll content and Specific Leaf Area (SLA). Whereas, traits days to 50 % flowering and days to maturity observations were recorded on plot basis in both the conditions. The means were subjected to analysis of variance by standard method of Steel and Torrie (1984). Genetics components of variance were obtained as outlined by Johnson *et al*. (1956) and Mahmud and Kramer (1951). Cluster analysis was used to arrange a set of variables (genotypes and traits) into clusters. Its objective was to sort variables into groups, so the magnitude of association was strong between members of the same cluster and weak between members of different clusters. Each cluster described the class to which its members belonged and this description may be abstracted through use of the particular to the general class or type. The cluster analysis was performed using a measure of similarity levels and Euclidean distance (Eisen *et al*., 1998) using Minitab version 14 package.

RESULTS ANDDISCUSSION

Analysis of variance for grain yield performance and other measured traits in both non-stressed and water-stressed environments indicated highly significant differences among thirty one mungbean genotypes. The average grain yield in non-stressed environment was 7.95 g per single plant and the mean yield performance in water-stressed environment was 3.59 g per single plant (Table 1). The maximum grain yield in non-stressed environment was 13.23 g while in water-stressed environment was 5.26g. The minimum grain yield in non-stressed environment was 3.86 g while in water-stressed environment was 2.04g (Table 1).

The coefficient of variation (CV) for all the genotypes ranges from 0.75% to 7.66% in non stressed environment and ranged from 0.61% to 14.56% in water stressed environment. The highest CV in non-stressed was reported in seed yield per plant (g) followed by number of clusters per plant and in water-stressed environments was observed in number of clusters per plant followed by number of pods per plant. The lowest CV in non-stressed was observed in days to maturity and in

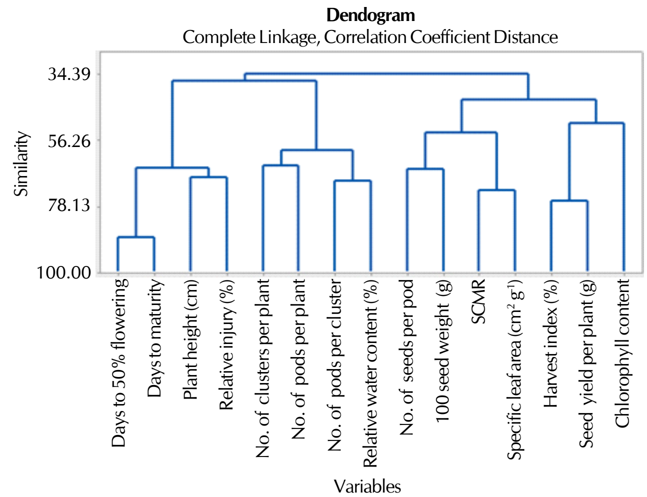

Figure 1: Similarity levels of the estimated traits (variables) in 31 mungbean genotypes using the hierarchical cluster analysis in non-stressed conditions

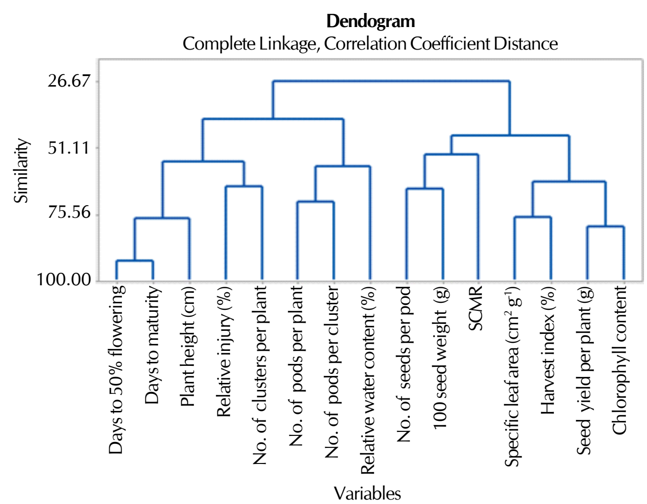

Figure 2: Similarity levels of the estimated traits (variables) in 31 mungbean genotypes using the hierarchical cluster analysis in stressed conditions

Table 1: Descriptive statistics for estimated traits of mungbean in non stressed and water stressed condition

	Non stressed condition					Stressed condition				
Trait	Mean	Minimum	Maximum	C.V. (%)	S.Ed.	Mean	Minimum	Maximum	C.V. (%)	S.Ed.
Days to 50% flowering	43.44	40.00	45.67	2.82	0.71	41.69	39.33	44.33	1.25	0.30
Days to maturity	68.79	65.33	71.00	0.75	0.29	64.67	62.00	68.00	1.69	0.63
Plant height (cm)	55.82	37.78	64.56	1.85	0.59	37.15	24.09	51.52	0.61	0.13
No. of Clusters per plant	9.86	7.67	12.33	5.69	0.32	4.87	3.62	7.33	14.56	0.41
No. of Pods per cluster	3.95	2.58	6.73	2.49	0.05	2.85	1.81	4.36	0.96	0.02
No. of Pods per plant	23.80	16.33	30.33	3.36	0.46	10.31	7.67	18.33	8.88	0.53
No. of Seeds per pod	10.23	8.76	12.88	1.26	0.07	8.23	6.00	10.67	3.96	0.19
100 seed weight (g)	4.07	3.01	6.34	1.59	0.04	3.56	2.62	5.31	1.20	0.02
Harvest index (%)	35.08	20.97	48.30	2.49	0.51	24.06	15.41	33.27	3.68	0.51
SCMR	46.51	40.50	52.97	1.44	0.38	42.86	37.94	49.13	3.44	0.85
Relative water content (%)	84.13	80.71	87.33	1.50	0.73	73.06	70.07	76.57	1.70	0.72
Relative injury (%)	27.92	13.59	46.50	4.82	0.77	14.55	8.48	33.33	8.38	0.70
Chlorophyll content	2.63	2.00	4.02	3.05	0.04	1.68	1.07	2.24	6.48	0.06
Specific leaf area ($cm^2 g^{-1}$)	125.58	90.27	178.97	3.55	2.57	101.76	64.88	127.56	4.56	2.68
Seed yield per plant (g)	7.95	3.86	13.23	7.66	0.35	3.59	2.04	5.26	2.08	0.04

Table 2: Mean performance of thirty one genotypes of mungbean for fifteen quantitative characters under non stressed condition

Sl. No.	Genotype	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of clusters /plant	No. of pods /cluster	No. of pods /plant	No. of Seeds /pod	100 seed weight (g)	Harvest Index(%)	SCMR	RWC (%)	Relative injury (%)	Chlorophyll content	Specific leaf area ($cm^2 g^{-1}$)	Seed yield/ plant(g)
1	AKM 9904	43.67	69.33	51.34	10.33	3.16	26	9.11	3.75	31.7	40.5	84.71	13.59	2.08	99.98	8.49
2	ASHA	45	70.67	62.33	8	3.78	25.33	10.4	3.67	32.41	47.47	81.69	17.11	4.02	137.63	4.84
3	COGG 974	45	70	52.33	9	3.45	25.33	10.1	3.55	36.71	45.37	86.01	44.16	3.37	129.51	11.46
4	EC- 396117	44	68.33	47.56	9.33	6.2	21	12.88	5.61	32.63	49.32	85.45	26.86	3.37	122.02	6.53
5	GVIT-203	43	69.33	62.67	8.33	5.96	24.67	11.79	3.45	37.81	45.2	86.51	21.67	2.95	156.45	6.55
6	IPM-02-03	40.33	65.33	47.96	11.33	2.91	30	9	4.25	25.49	47.43	81.53	40.45	2.89	102.47	5.83
7	IPM-02-19	42.67	69.33	62.55	10.67	3.49	27.33	10.59	4.6	48.18	49.68	83.58	45.24	2.57	114.99	13.23
8	KM-8-657	43.67	68.67	62.96	10	5.16	23	10.14	4.25	39.52	44.71	83.39	18.47	3	148.31	5.35
9	KM-122	44.33	68.67	59.55	9.33	3.81	23	10.98	4.74	34.77	45.4	84.7	25.66	2.7	124.11	8.39
10	LGG 407	43	69.33	64.56	11.67	4.49	26	10.28	3.23	30.31	45.33	84.15	46.5	2.83	143.19	6.06
11	LGG 410	45	69.67	61.31	8.67	3.11	25	9.72	3.59	35.7	46.13	83.4	42.52	2.83	143.39	4.35
12	LGG 450	44.67	68.33	62.44	10.67	5.62	21	10.49	3.26	35.72	42.62	82.49	34.77	2.27	111.71	5.2
13	LGG 460	45.67	71	62.3	9.33	3.06	17.33	10.91	3.01	28.12	42.57	83.9	35.65	2.58	161.59	6.35
14	LGG 528	42.33	67.33	57.11	11.67	3.44	25.67	8.76	3.31	29.23	44.76	83.49	34.37	2.81	178.97	3.86
15	MGG295	44	69.67	58.67	10	3.55	27.67	9.32	3.9	45.05	43.52	84.53	31.55	2.36	145.11	9.56
16	MGG347	44.33	69.33	54.22	9.33	3.96	16.33	11.48	3.88	34.1	46.37	87.33	15.47	2.59	104.55	9.34
17	MGG350	45	69.67	59.67	9.33	2.81	27.33	10.25	3.52	29.67	46.38	86.34	19.85	2.13	136.21	10.59
18	MH-3-18	41	67	37.78	12.33	3.05	21	9.27	3.74	29.24	46.37	85.21	29.45	2.66	109.47	10.19
19	MH-565	40.67	67.67	43	8.67	3.26	24.33	10.96	3.67	34.35	47.79	84.37	14.09	2.33	121.06	7.45
20	ML145	40.67	68	52.33	9	5.26	19.33	8.77	4.57	35.78	51.82	84.46	35.44	2.45	134.18	7.69
21	ML-267	44.67	69	52.11	10	3.25	20	10.75	3.09	38.36	43.27	84.18	17.8	2.73	133.73	9.58
22	PM110	43	67.67	55.22	10.67	3.34	28	10.31	4.36	40.6	49.37	84.39	16.67	2.73	118.86	10.4
23	PUSA 9531	45.67	70.33	60.45	11.33	3.66	27	9.8	3.36	39.8	47.22	82.99	37.85	2.33	110.09	10.35
24	PUSA VISHAL	44.67	69.67	57.52	7.67	6.73	26.33	10.52	4.06	33.55	42.7	84.1	15.64	2.21	90.27	5.32
25	RMG 492	40	65.33	50.89	10	3.51	25.67	10	4.25	48.3	52.97	86.44	17.19	2.25	105.73	10.91
26	TLM-7	43.67	68.33	60	10	3.45	16.67	10.19	5.22	33.05	46.1	83.08	17	3.06	106.5	6.48
27	TM 96-2	44.33	69.33	59.89	9.33	4.46	18	10.17	3.75	20.97	46.27	83.71	44.43	2.69	121.6	4.92
28	VG- 6197A	45	70.67	48.44	10	3.85	20	10.14	6.34	43.29	51.3	82.62	37.86	2.62	124.28	11.1
29	VG 7098A	40	66	47.33	8.33	5.17	19.33	10.22	3.83	26.73	49.7	84.73	16.76	2.03	92.4	7.06
30	WGG 2	42	69.33	54.77	12	3.03	30.33	9.41	5.37	41.9	46.93	80.71	24.06	2	128.61	10.65
31	WGG-37	45.67	70.33	61.45	9.33	2.58	30	10.27	5.01	34.43	47.3	83.74	27.45	2.08	136.15	8.42
	General Mean	43.44	68.79	55.82	9.86	3.95	23.81	10.23	4.07	35.07	46.51	84.12	27.92	2.63	125.58	7.95

SCMR: SPAD Chlorophyll Meter Reading and RWC: Relative Water Content

Table 3: Mean performance of thirty one genotypes of mungbean for fifteen quantitative characters under moisture stress condition

Sl. No.	Genotype	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of clusters/ plant	No. of pods /cluster	No. of pods/ plant	No. of Seeds /pod	100 seed weight(g)	Harvest Index(%)	SCMR	RWC (%)	Relative injury (%)	Chlorophyll content	Specific leaf area ($cm^2 g^{-1}$)	Seed yield/ plant(g)
1	AKM 9904	42.67	66.67	34.14	4.67	2.13	12.33	7	3.39	22.34	39.64	73.76	10.03	1.56	75.05	3.47
2	ASHA	42.33	63	33.69	3.67	3.23	11	7.67	3.28	22.58	46.78	70.07	11.94	1.64	127.56	3.27
3	COGG 974	43.33	66	40.26	5.33	2.64	10.67	8.33	3.15	18.66	42.23	72.59	16.58	2.14	100.43	3.61
4	EC- 396117	39.67	62	30.1	5.67	2.74	10	10.67	4.56	25.14	43.94	75.32	16.43	2.2	106.89	4.17
5	GVIT-203	41.67	65	51.52	3.67	4.06	10.33	9	3.06	33.27	49.13	76.57	14.26	1.51	115.65	3.19
6	IPM-02-03	39.67	63.33	29.39	4	2.04	8.67	8	3.68	20.79	44.6	75.17	13.64	1.63	99.49	2.04
7	IPM-02-19	40.33	63	34.37	4	2.58	11	9	3.72	25.41	44.67	71.32	19.84	1.33	107.7	4.07
8	KM-8-657	41.33	64	41.44	5	3.85	8.67	8	3.52	19.58	48.9	70.95	8.48	1.07	109.13	2.11
9	KM-122	40.67	63.67	37.33	4	2.18	9.67	9	4.25	21.4	43.27	72.54	12.18	1.95	102.76	2.98
10	LGG 407	42.33	67	29.85	4.33	3.54	11.67	8	2.67	24.34	42.7	75.13	12.55	1.76	108.55	2.57
11	LGG 410	44	66	43.35	5.33	2.38	10.33	8	3.25	18.81	41.93	74.57	18.91	2.19	124.77	4.05
12	LGG 450	43.33	67.33	46.63	6.33	4.27	9.67	8	3.06	28	42.97	72.51	21.13	1.67	92.19	5.03
13	LGG 460	44.33	67	39.46	4.67	2.09	8.33	9	2.62	23.64	41.27	72.3	19.36	2.12	84.13	3.69
14	LGG 528	41.33	65	39	5	2.35	9.67	7.33	2.75	23.45	41.37	73.62	11.56	2.24	123.58	2.55
15	MGG295	43.33	65	47.53	3.67	2.11	10.33	8	3.31	33.17	40.35	71.59	19.44	1.09	110.67	4.31
16	MGG347	42.67	67.33	49.49	5.67	3.13	8.67	7.67	3.22	27.37	40.2	76.43	33.33	1.87	64.88	4.27
17	MGG350	42.33	65	44.26	7.33	3.34	13.33	6	3.15	23.13	41.27	75.55	11.77	1.55	83.81	4.02
18	MH-3-18	40	62.67	25.07	4.33	2.24	8.33	7	3.46	21.02	43.54	72.51	21.74	1.37	91.31	2.97
19	MH-565	40	62.67	28.09	4	2.92	9	8.33	3.2	29.16	45.5	75.18	8.58	1.75	91.5	3.62
20	ML145	40.67	64.67	24.09	6	3.93	9.33	7.67	4.16	26.48	46	75.83	10.87	2.02	123.22	3.74
21	ML-267	40.67	64	42.41	3.67	1.81	7.67	10	2.74	24.05	39.55	71.39	11.93	1.93	109.1	4.52
22	PM110	42.33	65.33	31.25	4	1.91	9.33	8	3.94	25.59	41.03	74.3	10.08	1.95	96.78	4.37
23	PUSA 9531	43.67	64.33	38.44	5.67	1.96	9.67	8	3.14	15.41	40.77	70.38	13.94	1.14	100.99	2.57
24	PUSA VISHAL	40	62.67	45.51	5	4.36	12.33	8	3.62	27.17	37.94	74.77	9.58	1.7	86.32	3.06
25	RMG 492	40.33	63.33	35.33	6	3.43	18.33	8	3.52	30.55	44.65	76.14	10.19	1.38	100.17	5.04
26	TLM-7	42.33	65.67	27.5	5.67	2.52	8	8	4.26	25.17	39.75	73.02	10.45	1.97	100.25	3.07
27	TM 96-2	41.67	63.67	32.43	4.33	3.72	8.33	8	3.58	18.12	44.84	75.47	15.23	1.78	109.82	2.82
28	VG- 6197A	43.33	68	36.48	5.67	2.84	8.33	9	5.31	25.89	44.84	73.65	16.52	2.06	114.32	5.26
29	VG 7098A	39.33	63.67	26.65	4.33	3.61	10.33	8.67	3.67	19.15	43.08	73.67	11.69	1.19	83.48	3.17
30	WGG 2	41	64.67	48.37	4.67	2.16	11.67	8.67	4.88	19.84	40.09	71.58	18.36	1.09	89.74	3.13
31	WGG-37	42	63.33	38.09	5.33	2.45	14.67	9.33	4.33	27.34	42.13	73.97	10.7	1.49	120.49	4.61
	General Mean	41.69	64.68	37.15	4.87	2.85	10.31	8.24	3.56	24.06	42.86	73.6	14.55	1.68	101.76	3.59

SCMR: SPAD Chlorophyll Meter Reading and RWC: Relative Water Content

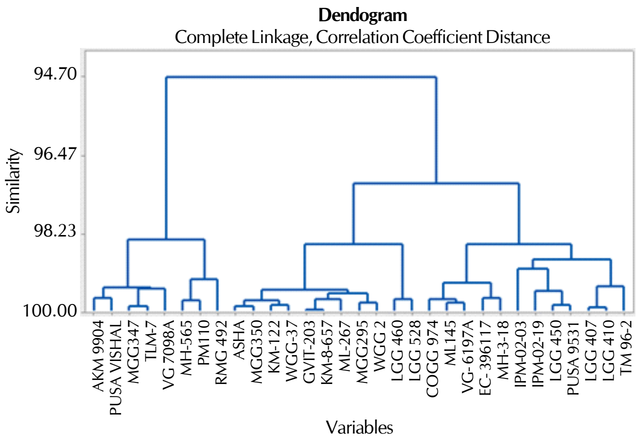

Figure 3: Similarity levels of the estimated thirty one mungbean genotypes using the hierarchical cluster analysis in non-stressed conditions

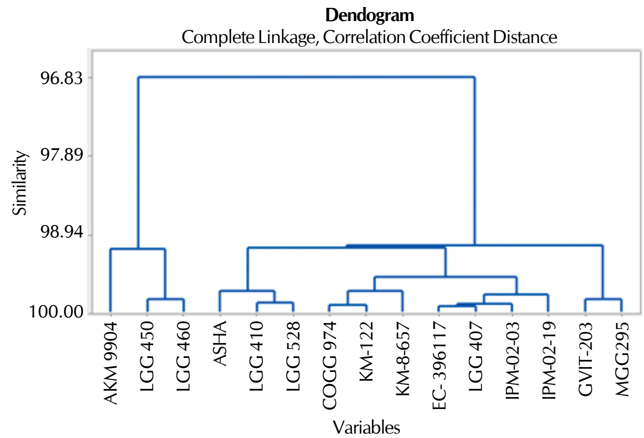

Figure 4: Similarity levels of the estimated thirty one mungbean using the hierarchical cluster analysis in water-stressed conditions

water-stressed environments lowest CV was observed in plant height (cm). The mentioned CV values of these mungbean genotypes indicated the presence of sufficient genetic variability to ensure positive response to crop improvement programs as selection and hybridization processes.

Clustering based on mungbean genotypes separated the measured traits into four main groups in non-stressed environment (Figure 1). There were days to 50% flowering, days to maturity, plant height and relative injury% traits in one cluster, number of clusters per plant, number of pods per plant, number of pods per cluster and Relative Water Content traits in the second cluster and 100 seed weight, SCMR and Specific Leaf Area in third cluster and likewise Harvest Index, seed yield per plant and chlorophyll content in fourth cluster in non stressed condition. Therefore, it seems that Harvest index and chlorophyll content were the most related traits with grain yield while some other important traits like number of clusters per plant, number pods per cluster and number of pods per plant were grouped in the other clusters. However, selection based on some identified traits regardless of interactions among them and with grain yield components may mislead the plant breeders to accomplish their main breeding purposes (Garcia del Moral *et al.,* 2003).

Clustering of the measured traits of mungbean genotypes in water-stressed environment indicated that days to 50% flowering, days to maturity, plant height, chlorophyll content and specific leaf area traits were grouped as one cluster, number of pods per cluster, number of seeds per pod and Relative Water Content traits were grouped as the other cluster, and number of clusters per plant, Relative Injury% and number of pods per plant traits were grouped as the other cluster and likewise, 100 seed weight, SCMR, Harvest Index and seed yield per plant were grouped in fourth cluster(Figure 2). Thus, it seems that 100 seed weight, SCMR and Harvest Index were the most associated traits with grain yield while some other important traits like number of seeds per pod, number of clusters per plant and number of pods per cluster were grouped in the other clusters. The traits 100 seed weight, SCMR and Harvest Index should be are primary selection criteria for improving grain yield in mungbean in low rainfall conditions.

Clustering based on studied traits separated the mungbean genotypes into three main groups under non stress condition (Figure 3). There were AKM 9904, PUSA VISHAL, MGG 347, TLM 7, VG 7098A, MH 565, PM 110 and RMG 492 genotypes in one group and genotypes ASHA, MGG 350, KM 122, WGG 37, GVIT 203, KM-8-657, ML 267, MGG 295, WGG 2, LGG 460 and LGG 528 in the other cluster and likewise, COGG 974, ML 145, VG 6197A, EC 396117, MH-3-18, IPM-02-03, IPM-02-19, LGG 450, PUSA 9531, LGG 410 and TM 96-2 were grouped in third cluster. Therefore, there is a significant difference between evaluated genotypes for morphological traits. Cluster 1 which included IPM-02-19, COGG 974 and VG 61974 had high mean yield under non-stressed conditions while cluster 2 and 3 which included the other remaining genotypes did not have high mean yield in such environmental conditions (Table 2). Therefore, it seems that for breeding grain yield in non-stressed conditions, genotypes included IPM-02-19, COGG 974 and VG 61974 are good candidates.

Clustering according to measured traits separated the mungbean genotypes into two main groups under water stress condition (Figure 4). The genotypes AKM 9904, LGG 450 and LGG 460 were grouped as one cluster and remaining twenty eight genotypes were grouped as one cluster. Cluster 2 which included VG 6197A and RMG 492 showed high grain yield performance under water-stressed conditions while cluster 2 which included genotype LGG 450 showed high mean yield and remaining genotypes indicated low mean yield in water-stressed environmental conditions Table 3. Therefore, it seems that for genetic improvement of high grain yield in mungbean in water-stressed conditions, genotypes VG 6197A, RMG 492 and LGG 450 are good candidates. Saxena *et al.*, 2005 categorized 59 genotypes using multivariate analysis into 16 well characterized groups. Phansak *et al.*, 2005 also clustered 15 accessions into three distinct groups. Studies conducted by Bisht *et al.*, 1998 showed that 111 mungbean accessions were grouped into six discrete and well-defined clusters. Pandiyan *et al.* (2012) subjected 646 greengram accessions into hierarchical cluster analysis which revealed eight distinct clusters.

Variation due to mungbean genotypes was significant for all traits in two environmental conditions (non-stressed and water-stressed conditions). This suggested that the observed differences in mungbean genotypes were sufficient to provide some facilities for selecting the most favorable genotypes to improve yield performance as well as drought tolerance. For a trait to be considered as a selection criterion in grain yield improvement program it must be associated with grain yield and it is therefore, essential to determine whether grain yield was associated with a particular trait. We found that Harvest index and chlorophyll content were the most related traits with grain yield and had high contribution to increasing grain yield in non-stressed conditions. Cluster analysis results proved that the above-mentioned traits were the variables most closely related to grain yield. These results suggest that selections should be based on the Harvest index and chlorophyll content for developing new mungbean cultivars.

The result of this research could be compromised from a broad diversity among studied mungbean genotypes. It seems that there is a high variation for number of clusters per plant among evaluated genotypes. For some genotypes, some measured traits were high and other traits showed low values and so consideration of few traits is not a suitable way for selecting the best genotypes. Similarly, various traits have interaction between each other, and effects of some traits make main traits such as grain yield. Although, in some areas where drought stress happens less frequently and where wet years predominate, improving grain yield under water-stressed conditions can usually be achieved by selecting for more productivity under non-stressed conditions, but such strategy is not good enough in most arid and semi-arid environments (Gohar *et al.,* 2015). In contrast, some researchers believe that this strategy as a traditional approach indicates selecting for high yield under non-stressed conditions (Rajaram *et al.,* 1996). Also, selection based on low yield performance decrease under water-stressed conditions with respect to favorable conditions tends to reduce yield under non-stressed conditions (Sio-Se Mardeh *et al.,* 2006).

In this research, the association was observed between grain yield and 100 seed weight, SCMR, Harvest index under water-stressed conditions. Cluster analysis results indicated that the above-mentioned traits were the variables most closely related to grain yield. The grain yield, a major selection criterion versus drought stress, is a complex trait determined by several processes and its genetics are greatly am-biguous (Mir *et al.,* 2012). The traits such as 100 seed weight, SCMR and Harvest index had association with grain yield in dryland condition, indicating its importance for selection drought tolerance as well as higher yield performance. Accordingly, to increase grain yield under dryland conditions, the more focus should be on physiological traits such as SCMR, SLA, RI %, RWC and chlorophyll content which have a high correlation with grain yield and also should utilize them in drought tolerance breeding programs.

Cluster analysis based on the phenotypic trait data assigned the mungbean genotypes to at least three major groups in non-stressed conditions and to two major groups in water-stressed conditions. Genotypes are distributed among all cluster groups, which implied that genetically different genotypes were identified with grain yield performance. It is reasonable to assume that the genetic basis of grain yield and other measured traits in these genotypes is different, which would enable mungbean breeders to combine these different sources of genetic variability to improve grain yield as well as other measured traits in their breeding programs.

Maximum genetic variation is expected from crosses that involve parents from clusters characterized by maximum distance. Crosses between genotypes selected on the basis of special merits are, therefore, expected to provide relatively better genetic recombination in their progenies. Hence, it seems that for improving grain yield performance in non-stressed conditions, genotypes IPM-02-19, COGG 974, VG 61974 and RMG 492 and in water-stressed conditions, genotypes VG 6197A, RMG 492 and LGG 450 are good candidates. It is interesting that genotypes VG6197A and RMG 492 can be used for obtaining high grain yield performance in both conditions.

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