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Character Association and Genetic Diversity in Rainfed Greengram [*Vigna radiata (*L.) Wilczek]

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ABSTRACT: Sixteen greengram genotypes were evaluated for their yield performance as well as inter-relationship among morphological traits and genetic diversity. The variation in shoot weight, root weight, nodules/plant and nodule weight was quite high among varieties ranging from 2.62-9.20 g, 0.18-0.49 g, 16.5-28.5 and 60.23-154.35g, respectively per plant. The mean number of days taken to flowering was 38.78 ranging from 32.66 in OUM 11-5 to 71.0 in Phulbani Black mung. The most promising varieties with respect to yield were found to be Pusa 9531 and Dhauli (more than 7.0 q/ha). The number of pods/plant, pod length and seeds/pod exhibited significant positive correlation with greengram yield. However, the association of seed yield with days to 50% flowering, maturity duration, plant height and dry biomass was found to be significantly negative. Based on the dendrogram depicting the morphological similarity, the varieties were classified under three distinct main clusters. The local type, Phulbani Black mung was found to be most divergent from other greengram varieties and could be better exploited in crop improvement.

Key words: Greengram, varietal performance, character association, genetic diversity

Evaluation of varieties holds a key role in increasing production of different crops over time particularly in the context of climate change. As yield is a complex trait influenced by many other attributes, study on association among yield attributing traits is very important. Similarly, investigation on diversity among genotypes based on variation in different traits helps in identifying most divergent parents for exploiting higher heterosis in hybrids as well as transgressive segregation in improved varieties. The spectrum of variability in segregating generations is a function of genetic diversity among parents involved in hybridization and crop improvement largely depends upon such variability (Roy *et al*., 2002). Genetically distinct phenotypes identified using molecular (Karuppanapandian *et al*., 2006) or morphological markers could be potential sources of germplasm for greengram improvement.

Pulses are regarded as suitable crops for the rainfed areas due to their low water requirement and high drought tolerance. They contribute most towards combating protein deficiency among poor farmers. Legumes in crop sequences are also important for their residual effect with an advantage of 25-30 kg N/ha for the succeeding crop. Some pulses like greengram, blackgram, cowpea, etc. are grown in both *kharif* and *rabi* seasons while crops like gram and pea are almost raised in *rabi*. Similarly, while pulses like garden pea, soybean or French bean are mostly grown under irrigated condition, many others are seldom irrigated. About 90% area under pulses in India is rainfed as compared to 94% in Odisha. Thus, pulse crops like greengram which can be grown in both the seasons hold much importance in Odisha. The area under pulses including greengram has not increased in tune with the demand. Low productivity has also been one of the major bottlenecks in fulfilling demand for pulses. The prime cause for the low productivity can be ascribed to the inherently low yield potential of the cultivars coupled with susceptibility to insect pests and diseases besides management factors. Since the per capita availability of pulses in our country has declined from 69 g/day in 1961 to less than 30g at present against the minimum requirement of 50g, there is an urgent need to increase pulse production. So, in addition to better agronomic management, there is a need to evaluate varieties under different eco-systems.

Greengram is the most important pulse crop of Odisha accounting for 37.8% of the total pulse area and 33.7% of pulse production. It also contributes 7% of the total pulse production in India. The protein content in greengram is quite high (around 24%) which is comparatively rich in lysine, an amino acid generally deficient in cereals (Baskaran *et al*., 2009). Besides utilization of seeds as dal and other food products, sprouted seeds are a good source of vitamin 'C'. Greengram [*Vigna radiata* (L.) wilczek] is the most widely distributed among six Asiatic *Vigna* species (Pandiyan *et al*., 2012) having short-duration of 60-75 days. It is mostly grown as a sole crop but sometimes as an intercrop with other high value crops like maize and cotton. There are two major pulse growing seasons in Odisha: *kharif* (36% pulse area) and *rabi* (64% pulse area). Although greengram is grown as a *rabi* crop in coastal districts of Odisha, it is cultivated during *kharif* season in hilly districts like Kandhamal. Since approximately 90% cultivable land in *kharif* is rainfed in Kandhamal district belonging to N-E Ghat zone of Odisha, India and cessation of monsoon is quite unpredictable, growing a low water requiring and drought tolerant but highly nutritive pulse crop like greengram in rainfed uplands is likely to be more sustainable and remunerative.

Crop improvement in greengram has been comparatively slow due to limited variability among parents utilized. Study on genetic diversity helps in selection of divergent parents for hybridization to develop an elite cultivar (Bhatt, 1970). Keeping these points in view, the present investigation was undertaken to- (a) identify promising greengram varieties for higher yield when sown in late kharif under upland situation; (b) study on the association between yield attributing traits; and (c) elucidate genetic diversity among varieties so as to choose divergent parents for crop improvement.

Materials and Methods

Location and Experimental set up

The experiment was carried out in a randomized block design with two replications at the Research Farm of AICRP for Dryland Agriculture, Odisha University of Agriculture and Technology, Phulbani located in N-E Ghat zone of Odisha, India during *kharif* season from 2006 to 2008. The soil at the experimental site was sandy-loam with field capacity of 13.1%, permanent wilting point 5.5%, pH 6.0, organic carbon 0.32%, available P_2O_5 14 kg/ha and available K_2O 14 kg/ha. Genetically pure seeds of 16 greengram varieties were sown in lines 30cm apart with a seed rate of 25 kg/ha. Sowing was always made during first week of August avoiding heavy rainy days. All the manures and fertilizers were applied before sowing and there was no top-dressing. The applied nutrients included 5 t/ha FYM and 20:40:20 kg N -P_2O_5-K_2O/ha. Standard agronomic practices were followed to raise a good and healthy crop.

Observations recorded

In order to investigate association between yield and yield attributing traits as well as variability among different genotypes, data on 15 important biometric characters were recorded at different dates after sowing. Observations included- (i) characters at 30 DAS such as, fresh shoot weight/plant (g), fresh root weight/plant (g), nodules /plant and nodule weight (mg/plant); (ii) important phenological characters such as, days taken to 50% flowering and maturity; and (iii) prominent yield attributes at harvest such as plant height (cm), pods/plant, pod clusters/plant, pod length (cm), seeds/pod, 1000 seed weight (g), seed yield (q/ha) and dry plant biomass (q/ha). Harvest index was calculated through dividing seed yield by total plant biomass. The experimental data on most biometric characters was based on measurements of ten plants randomly chosen in the fields for each cultivar and replication. Observations at 30 days after sowing were taken by carefully uprooting plants from moist soil and gently washing the roots in clean water without losing the nodules. Then plants were kept on blotting paper for some time to soak the water on plant surface and weight of root, shoot and nodules were taken.

Statistical analysis

Statistical analysis was done for the data carried out by assigning the treatments according to randomized block design with two replications. The means of different treatments were compared as per LSD (least significant difference) at p= 0.05. The association among different traits was found out by estimating correlation coefficient values following Gomez and Gomez (1984).

Results and Discussion

Weekly rainfall variation over years during crop growth stages

The data on normal weekly rainy days and rainfall (mm) as well as its variation during 2006 to 2008 in crop growing period (Figures 1a & 1b) showed high probability of rainfall from end of July to September. In all the three years of experimentation, greengram seeds were sown during 1st week of August to avoid excess rainfall during flowering stage and to raise the crop under conditions when there was probability of adequate rainfall for different growth stages in most of the varieties. However, in spite of these precautions, the crop actually encountered excess or deficit moisture during critical growth stages (Table 1) that probably resulted in yield variation.

Variation in yield and yield attributes among genotypes

Based on the yield performance of 16 greengram varieties over 3 years from *Kharif* 2006 to *Kharif* 2008, the mean seed yield varied from 0.33 q/ha in Phulbani Black mung to 7.75 q/ha in Pusa 9531 (Table 2). Remarkable variation was also observed within a variety in three different years which clearly shows the effect of rainfall variation on greengram yield. The mean seed yield of 16 varieties during 2006, 2007 and 2008 were found to be 7.05, 3.76 and 5.21 q/ha, respectively. Long maturity duration of Phulbani Black mung seemed to play the major role for its lowest yield due to soil moisture scarcity during pod development. Both Pusa 9531 and Dhauli produced average seed yield of more than 7.0 q/ha and are thus most suitable for the N-E ghat zone of Odisha. Other varieties which yielded more than 6.0 q/ha were OBGG-52, OUM-7 and ML-5 which could also be profitably cultivated in this agro-climatic zone. Among the local varieties, Nayagarh Local produced highest yield (4.54 q/ha) followed by Boudh Local (4.05 q/ha) and the yield of Phulbani Black mung was the lowest (0.33 q/ha).

Considerable variation was observed among 14 important quantitative and yield attributes of greengram investigated in our study (Table 3). At 30 days after sowing, the mean fresh weight/plant of root and shoot were found to be 4.88g and 0.30g, respectively. However, the variation in shoot and root weight among varieties was quite high ranging from 2.62-9.20 g/plant and 0.18-0.49 g/plant, respectively. Both shoot and root weights were highest in Phulbani Black mung while nodules/plant as well as nodule weight were maximum in K-851. The number of nodules/plant and nodule weight varied from 16.5-28.5 and 60.23-154.35g, respectively in different varieties showing variation in nodulation among genotypes as well as differential response to native rhizobia present in soil. Days to 50% flowering and maturity were found to be earliest in OUM-11-5 while Phulbani Black mung exhibited longest maturity duration.

The variety, OUM-11-5 exhibited the lowest plant height of 37.8 cm while Phulbani Black mung had the highest plant height (88.8 cm). The average number of pods/plant, pod clusters/ plant, seeds/pod and 1000-seed weight was found to be 10.972, 4.631, 12.081 and 18.648 g, respectively. The pod length varied from 5.55 to 7.51 cm. Total plant dry biomass was maximum in Phulbani Black mung and lowest in K-851. Highest biomass coupled with lowest seed yield in Phulbani Black mung resulted in lowest harvest index which clearly indicates importance of partitioning in greengram.

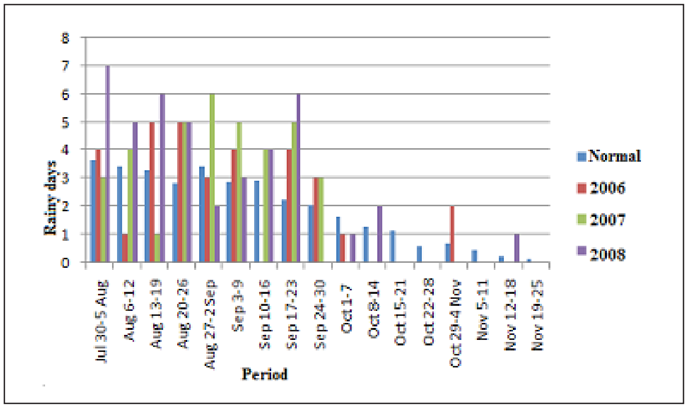

Fig. 1(a) : Weekly rainy days at Phulbani during crop growing period

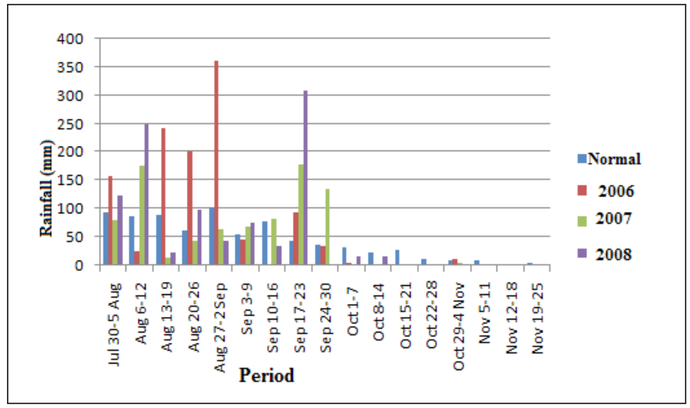

Fig. 1(b) : Weekly rainfall (mm) at Phulbani during crop growing period

Table 1 : Unfavourable weather conditions during cropping years

Parameters	2006	2007	2008
Date of sowing	05.08.2006	01.08.2007	02.08.2008
Crop seasonal rainfall	1012.2 to 1022.8 mm	829.2 mm to 830.2 mm	856.7 mm to 887.7 mm
Effect of dry spells	High rainfall during vegetative and flowering stages. Cessation of rainfall from 2.11.2006 resulted in retardation of pod development in one variety, Phulbani Black mung (Local) that had a long maturity period (115 days).	No rainfall after 28.09.2007 (59 DAS) affecting pod development.	Continuous long dry spell of 11 days from 24th September to 4th October affecting pod development in many varieties and complete cessation of rainfall after 9th October affecting flowering and pod development in Phulbani Black mung.
Average green gram yield (q/ha)	7.05	3.76	5.21

Character association

Days to 50% flowering exhibited significantly high positive correlation with maturity duration (Table 4). These two characters exhibited similar type of association with the other characters, that is, significantly positive correlation with plant height as well as shoot and root biomass but negative correlation with pod length, seed yield and harvest index. This shows that although long maturity duration helped in more accumulation of photosynthates resulting in higher biomass, partitioning of assimilates might has been affected in late maturing varieties due to water scarcity at terminal growth stage of the crop. Dry plant biomass at harvest exhibited significantly positive correlation with fresh root and shoot weights at 30 DAS which clearly shows that early plant vigour in greengram is associated with final biomass at harvest. Similarly, the shoot and root biomass at 30 DAS had strong positive correlation. Number of nodules/plant showed significant positive correlation with nodule mass which can facilitate one to screen for high nodulating genotypes based on nodule number *per se.* Strong positive correlation was also observed between seeds/pod and pod clusters/plant. In earlier studies, the number of pods per cluster, pod length and number of seeds per pod had also positive direct effect on seed yield (Venkateshwarlu, 2001) and seeds/pod contributed maximum towards genetic divergence (Naidu and Satyanarayana, 1991, Bisht *et al*., 1998). In another study on genetic diversity using multivariate analysis with 33 genotypes of greengram, it was observed that 1000-seed weight contributed the most towards total divergence (Manivannan, 2002). Additive gene effects for 1000 seed weight, pods per plant and seeds per pod indicate that improvement in these traits may be achieved by phenotypic selection (Makeen *et al*., 2007).

The number of pods/plant, pod length and seeds/pod exhibited significant positive correlation with greengram yield but the association of seed yield with days to 50% flowering, maturity duration, plant height and dry biomass was found to be significantly negative. Since water scarcity at later growth stages resulted in lowest seed yield and harvest index of Phulbani Black mung, it is advisable to grow greengram varieties maturing within 75 days in N-E ghat zone of Odisha which has been supported by the negative association between maturity duration and seed yield.

Table 2 : Year-wise yield data of greengram varieties at Phulbani during 2006 – 08

Greengram variety	Seed yield (q/ha)			
	2006	2007	2008	Mean
ML-5	7.67	4.51	6.66	6.28
Dhauli	10.91	3.99	8.04	7.65
Pusa-9531	8.76	6.28	8.22	7.75
Samrat	8.80	1.59	5.96	5.45
OUM-7	7.61	5.90	5.38	6.30
HUM-1	4.94	4.28	3.82	4.35
OBGG-66	6.83	3.88	4.40	5.04
OUM 11-5	7.04	4.95	3.99	5.33
OBGG-52	8.02	5.90	5.56	6.49
ML-131	6.28	3.44	5.84	5.19
K 851	6.85	3.96	5.03	5.28
Sujata	8.00	5.32	4.40	5.91
PDM-54	5.72	4.17	6.71	5.53
Phulbani Black mung	0.45	0.24	0.31	0.33
Nayagarh Local	8.20	1.07	4.34	4.54
Boudh Local	6.76	0.69	4.69	4.05
Mean	7.05	3.76	5.21	5.34
SE(m)+	0.97	0.19	0.44	-
LSD (0.05)	2.96	0.58	1.33	-

Genetic diversity among greengram genotypes

Genetic diversity in any crop is very important and must be carried out time to time because variation among different genotypes was found to have no relationship with the locality of adaptation which agreed with observations of earlier workers that geographic diversity could not always be used as an index of genetic diversity (Arunachalam and Ram, 1967; Gupta and Singh, 1970). Exploration of genetic divergence over stress and non-stress environments in mungbean could help in identifying suitable parents under different ecosystems (Patil *et al*., 2003).

In this study, a non-hierarchical cluster analysis of greengram varieties based on 15 different characters classified them into three distinctive main clusters (Figure 2). Cluster I and Cluster II had only one variety each, namely Phulbani Black mung and K-851, respectively. Cluster III was further divided into two sub-clusters, Sub-cluster IIIa comprising Boudh Local, Sujata, OUM-7 and Dhauli while Sub-cluster IIIb included Pusa-9531, Nayagarh Local, OUM-11-5, HUM-1, PDM-54, ML-131, OBGG-52, OBGG-66, Samrat, and ML-5. However, the dissimilarity coefficient values between varieties ranged from 1.44 to 32.29% which indicated a narrow genetic base of tested greengram genotypes. This is in contrast to considerable diversity among greengram varieties with respect to yield, growth attributes and reaction to biotic and abiotic stresses because of self pollinated nature of this crop (Bisht *et al*., 2005).

Breeding for promising genotypes thus requires identification of yield attributes and their association as well as determining variability among varieties. Hierarchical cluster analysis and principal component analysis of 646 accessions of greengram germplasm revealed eight distinct clusters indicating the existence of enormous genetic diversity within the germplasm (Pandiyan *et al*., 2012). The extent of genetic diversity in several greengram landraces collected from various localities of Southern Tamil Nadu, India at DNA level by random amplified polymorphic DNA (RAPD) analysis using 20 decamer primers exhibited 83.0% polymorphism with 200 bands and Jaccard's similarity coefficient ranging from 64-93% indicated narrow genetic base (Karuppanapandian *et al*., 2006). Thus, the magnitude of genetic diversity depends upon varieties included in the study.

The reasonable variability among tested genotypes of the present investigation is worth consideration for breeding purposes. The

Table 3 : Important morphological and yield attributes of greengram varieties (mean of 3 years' data)

Variety		Fresh shoot wt/ plant(g) (30DAS)	Fresh root wt/ plant (g) (30DAS)	Nodules /plant	Nodule wt (mg/ plant)	Days to 50% flowering	Days to Maturity	Plant height (cm)	Pods /plant	Pod clusters /plant	Pod length (cm)	Seeds /pod	1000 seed wt (g)	Dry plant biomass (q/ha)	Harvest index
ML-5		5.280	0.310	21.350	111.075	37.333	71.000	55.700	13.133	4.200	7.145	11.700	19.675	37.875	0.166
Dhauli		6.000	0.360	21.350	133.175	38.333	71.667	57.317	13.433	4.900	7.510	12.800	21.640	48.670	0.157
Pusa-9531		7.800	0.470	16.500	66.775	35.333	71.667	50.833	13.333	4.500	7.320	12.250	21.000	32.820	0.236
Samrat		4.780	0.310	17.400	105.200	38.000	70.333	52.600	11.633	5.900	7.040	12.750	16.550	23.125	0.236
OUM-7		4.020	0.210	17.150	64.950	36.333	70.333	49.367	11.433	4.500	7.045	12.150	19.765	31.070	0.203
HUM-1		4.760	0.240	20.100	97.350	36.667	67.667	43.100	9.367	3.600	6.830	12.000	17.665	22.970	0.189
OBGG-66		4.440	0.310	19.700	115.500	34.333	69.667	44.800	10.333	4.200	6.555	11.500	20.425	22.440	0.225
OUM-11-5		5.210	0.300	17.400	98.300	32.667	62.333	37.800	8.267	3.800	6.805	11.850	19.700	19.090	0.279
OBGG-52		4.680	0.310	20.450	111.375	35.333	68.000	45.533	12.000	4.000	6.980	11.350	20.400	24.510	0.265
ML-131		4.130	0.250	24.150	117.900	37.667	70.000	48.300	10.300	4.000	7.345	11.950	20.750	22.595	0.230
K-851		4.450	0.290	28.500	154.350	35.000	67.333	47.500	10.833	3.600	6.760	12.200	19.600	16.485	0.320
Sujata		2.620	0.200	17.150	60.225	36.333	64.000	45.367	9.733	4.700	6.850	11.950	16.900	27.205	0.217
PDM-54		4.680	0.380	18.050	114.000	37.500	68.500	57.300	10.150	4.300	6.310	12.400	12.400	31.325	0.177
Phulbani-Black-mung		9.200	0.490	24.500	73.850	71.000	115.000	88.800	7.300	4.300	5.550	10.900	19.400	78.250	0.004
Nayagarh-Local		3.250	0.220	17.100	90.725	39.000	69.333	46.933	11.300	6.200	6.905	12.450	16.300	20.065	0.226
Boudh-Local		2.760	0.180	16.600	71.900	39.667	73.333	48.667	13.000	7.400	6.805	13.100	16.200	17.495	0.231
Mean		4.88	0.30	19.841	99.166	38.781	71.885	51.245	10.972	4.631	6.860	12.081	18.648	29.75	0.210
Range	**Min**	2.62	0.18	16.500	60.225	32.667	62.333	37.800	7.300	3.600	5.550	10.900	12.400	16.490	0.004
	Max	9.20	0.49	28.500	154.350	71.000	115.000	88.800	13.433	7.400	7.510	13.100	21.640	78.25	0.320

Table 4 : Correlation coefficient values among 14 morphological and yield attributing characters of greengram

Variety	Days to 50% flowering	Days to maturity	Nodules /plant (30DAS)	Nodule wt (mg/plant) (30DAS)	Plant height (cm)	Pods /plant	Pod clusters /plant	Pod length (cm)	Seeds /pod	1000 seed wt (g)	Dry plant biomass (q/ha)	Harvest index	Fresh shoot wt/ plant (g) (30DAS)	Fresh root wt/ plant (g) (30DAS)	Seed yield (q/ha)
Days to 50% flowering	1.00	0.98**	0.29	-0.33	0.92**	-0.45	0.06	-0.71**	-0.43	-0.01	0.85**	-0.84**	0.62**	0.50*	-0.80**
Days to maturity		1.00	0.34	-0.25	0.93**	-0.36	0.04	-0.68**	-0.45	0.10	0.86**	-0.82**	0.70**	0.57*	-0.74**
Nodules/plant			1.00	0.64**	0.30	-0.21	-0.56*	-0.22	-0.47	0.39	0.20	0.10	0.41	0.36	-0.26
Nodule wt (mg/plant)				1.00	-0.23	0.10	-0.42	0.11	-0.11	0.13	-0.36	0.60*	0.14	0.29	0.21
Plant height (cm)					1.00	-0.22	0.03	-0.60*	-0.32	-0.01	0.92**	-0.84**	0.70**	0.65**	-0.57*
Pods/plant						1.00	0.42	0.72**	0.57**	0.17	-0.22	0.20	-0.17	-0.10	0.69**
Pod clusters /plant							1.00	0.09	0.66**	-0.41	-0.14	-0.27	-0.35	-0.32	-0.10
Pod length (cm)								1.00	0.50*	0.37	-0.46	0.51*	-0.32	-0.34	0.84**
Seeds/pod									1.00	-0.38	-0.42	0.17	-0.44	-0.36	0.39
1000 seed wt (g)										1.00	0.21	0.10	0.40	0.23	0.25
Dry plant bio-mass (q/ha)											1.00	-0.83**	0.78**	0.68**	-0.40
Harvest index												1.00	-0.46	-0.35	0.54*
Fresh shoot wt/ plant (g)													1.00	0.93**	-0.22
Fresh root wt/ plant (g)														1.00	-0.10

* and ** Significant at 5% and 1% levels, respectively.

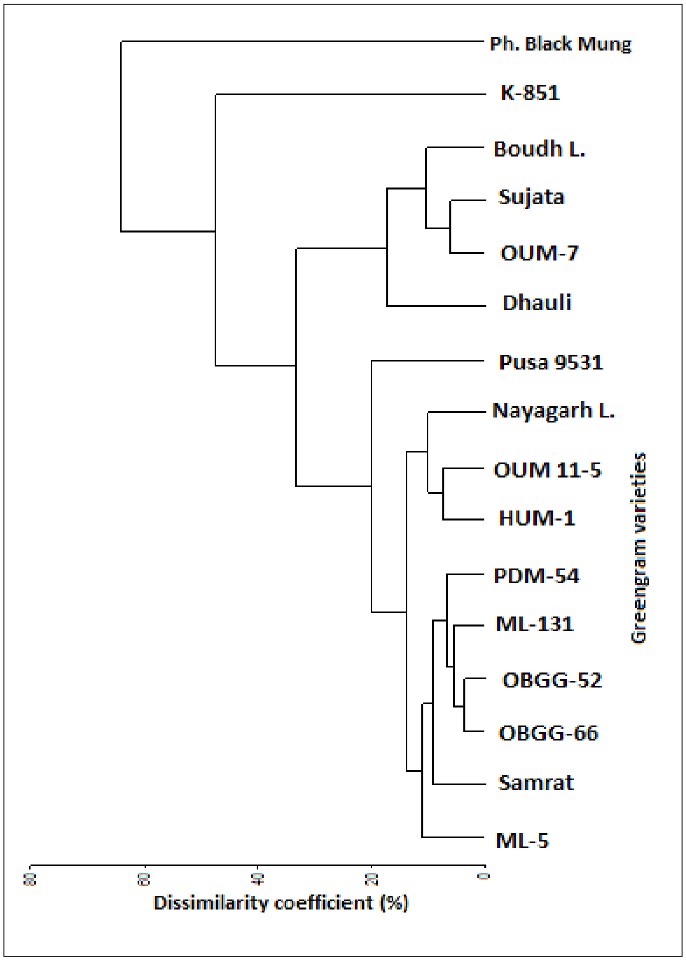

Fig. 2 : Dendrogram showing diversity among greengram varieties

local type, Phulbani Black mung was found to be most divergent from other greengram varieties and could be better exploited in crop improvement. Similarly, the improved variety, K-851 could be crossed with other greengram varieties to give rise to more transgressive segregants/promising varieties. The varieties, OBGG-52 and OBGG-66, exhibited the least dissimilarity. Genotypes within a cluster should not be utilized in crossing programmes since greater diversity between parents could only result in higher heterosis and transgressive segregation.

Conclusion

The crop improvement in greengram has achieved little success due to the limited variability among the parents used for hybridization. There is tremendous scope for improving the crop through incorporation of diversified gene present in the germplasm. In order to manipulate available variation, it is necessary to critically characterize and evaluate the available germplasm collections. The present investigation highlights the most suitable greengram varieties for N-E ghat zone of Odisha, important characters having strong positive correlation with yield and extent of diversity among the genotypes. Significant differences in seed yield have been observed due to rainfall variation in different years.

References

Arunachalam V and Ram J. 1967. Geographic diversity in relation to genetic divergence in cultivated sorghum. Indian Journal of Genetics and Plant Breeding, 27: 369-380.

Baskaran L, Sundararamoorthy P, Chidambaram ALA and Ganesh KS. 2009. Growth and physiological activity of greengram (*Vigna radiata* L.) under effluent stress. Botany Research International, 2 (2): 107-114.

Bhatt GM. 1970. Multivariate analysis approach to selection of parents for hybridization aiming at yield improvement in self pollinated crops. Australian Journal of Agricultural Research, 21: 1-7.

Bisht IS, Mahajan RK and Kawalkar TG. 1998. Diversity in greengram (*Vigna radiata* (L.) Wilczek) germplasm collection and its potential use in crop improvement. Annals of Applied Biology, 132: 301-312.

Bisht IS, Bhat KV, Lakhanpaul S, Latha M, Jayan BK, Biswas BK and Singh AK. 2005. Diversity and genetic resources of wild *Vigna* species in India. Genetic Resources and Crop Evolution, 52: 53-68.

Gomez KA and Gomez AA. 1984. Statistical procedures for Agricultural Research. Wiley Publications. New York. pp. 148-152.

Gupta MP and Singh KB. 1970. Genetic divergence for yield and its components in greengram. Indian Journal of Genetics and Plant Breeding, 30: 212-221.

Karuppanapandian T, Karuppudurai T, Sinha PB, Hamarul HA and Manoharan K. 2006. Genetic diversity in greengram [*Vigna radiata* (L.)] landraces analyzed by using random amplified polymorphic DNA (RAPD). African Journal of Biotechnology, 5(13): 1214-1219.

Makeen K, Garad A, Arif J and Singh KA. 2007. Genetic variability and correlation studies on yield and yield components in mungbean [*Vigna radiata* (L.) Wilczek]. Journal of Agronomy, 6: 216-218.

Manivannan N. 2002. Genetic diversity in cross derivatives of greengram [*Vigna radiata* (L.) Wilczek]. Legume Research, 25 (1): 50-52.

Naidu NV and Satyanarayana A. 1991. Studies on genetic divergence over environments in mungbean [*Vigna radiata* (L.) Wilczek]. Indian Journal of Genetics and Plant Breeding, 51: 454-460.

Pandiyan M, Senthil N, Packiaraj D, Gupta S, Nadarajan N, Thanga Pandian R, Suresh R and Jagadeesh S. 2012. Characterisation and evaluation of 646 greengram (*Vigna radiata*) genotypes for constituting core collection. Wudpecker Journal of Agricultural Research, 1(8): 294-301.

Patil BL, Hegde VS and Salimath PM. 2003. Studies on genetic divergence over stress and non-stress environments in mungbean. Indian Journal of Genetics and Plant Breeding, 63: 77-78.

Roy B, Basu AK and Mandal AB. 2002. Genetic diversity in rice *(Oryza sativa*) genotypes under humid tropics of Andaman based on grain yield and seed characters. Indian Journal of Agricultural Sciences, 72 (2): 84-87.

Venkateshwarlu O. 2001. Correlation and path analysis in greengram. Legume Research, 24: 115-117.

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