WFL Publisher
Science and Technology

Meri-Rastilantie 3 C, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

Journal of Food, Agriculture & Environment Vol.5 (1) : 224-227. 2007

www.world-food.net

Multivariate analysis of the genetic diversity of pigeon pea germplasm from south-west Nigeria

S. R. Akande

Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, P.M.B. 5029 Ibadan, Nigeria.
e-mail: remiajibade2002@yahoo.com

Received 18 September 2006, accepted 6 January 2007.

Abstract

Germplasm collection of pigeon pea in three states (Oyo, Ondo and Ekiti) of south-west Nigeria were undertaken in 2003. The 59 collections were evaluated for genetic variability in the field. Principal component and K-means clustering analyses were used to classify the collections. The principal component analysis attributed higher loadings to eight characters, number of days to 50% flowering, plant height, pod and seed weights per plant, number of secondary branches per plant, pod length and mid leaflet length. This result indicates the importance of these characters in delineating the collections. Although significant differences were observed among the collections for the characters evaluated, 73% of the collections were grouped into 2 of the 4 clusters formed by K-means analysis. These two clusters were the most closely related with the least inter-cluster distance of 79.88 units. These results show the low level of genetic diversity among the pigeon pea collections from the three states, which can be improved through mutation breeding, introduction and recombination. However, candidate varieties may be selected from Cluster 3 which had good yield attributes for recommendation to farmers.

***Key words*:** Cluster analysis, morphological characters, Nigeria, pigeon pea, variation.

Introduction

Pigeon pea (*Cajanus cajan* (L.) Millsp) is a leguminous crop grown in the tropics and subtropics. Nigeria is endowed with favourable ecologies for pigeon pea cultivation, although the crop is of low economic interest in the country as it is highly underutilized. It is presently grown by subsistence farmers with little or no inputs with resultant low yield [11]. However, with the recent upsurge of interest in underutilized crops, pigeon pea is receiving considerable attention. The origin of the species is controversial but according to FAO [2], it originated in both Africa and Asia. India is the major world producer (90%) of pigeon pea [9] while in Africa, Kenya is the largest producer followed by Uganda [3, 7]. The value of this crop is not well appreciated in West Africa [8]. In the south-western part of Nigeria, pigeon pea is traditionally called ‘otili’ among the Yoruba speaking people. It is often planted as hedges to mark farm boundaries and at backyard of dwelling places or as a cover crop [1]. It is also intercropped with other crops such as maize and yam [13]. As a legume, it is highly proteineous and the seeds can be prepared into various meals and serves as a substitute for cowpea. The pods, seeds and leaves are excellent fodder for cattle, sheep and goats [18].

Pigeon pea has received little research attention in Nigeria in term of crop improvement, and the traditional varieties are still being cultivated by the farmers. It is therefore important to determine the genetic diversity of the crop as a prerequisite to crop improvement. It is necessary to know the potentials for use of any available collections for efficient utilization. This is achieved through characterization and evaluation. Previous studies have shown limited level of genetic diversity among the cultivated pigeon pea [5, 10, 14]. Recently, the genetic variability among East African and Asian originated pigeon pea varieties was studied using AFLP [15]. It was shown that East African pigeon peas were closely related and less genetically diverse than Indian cultivars. In the present study, the genetic variation for morphological characters among pigeon pea collections from three states in south-western Nigeria was studied using principal components and K-means clustering analyses. The information would aid in selection and adoption of appropriate improvement strategy for the crop.

Materials and Methods

Germplasm collections of pigeon pea from Oyo, Ondo and Ekiti states of south-west Nigeria were carried out between June and December 2003. The three states fall within the humid forest environment of the region. The geographic characteristics of each of these states are shown in Table 1. Seeds were collected directly from the farmers at their farms and at homes. Seeds were also collected from the local markets on market days. There were 23 collections from Oyo, 21 from Ondo and 9 from Ekiti States. Five and one accession(s) respectively were also supplied by the International Institute of Tropical Agriculture (IITA) and National Center for Genetic Resources and Biotechnology (NACGRAB) both located in Ibadan. The socio-economic characteristics and production system of pigeon pea and other underutilized grain legumes in the region have been described by Saka *et al.* [11]. A total of 59 collections were evaluated. The collections were numbered serially from 1 to 59 according to the time of collection. The seeds were sorted and planted out at the Research Farm of the Institute of Agricultural Research and Training, Moor Plantation, Ibadan, Nigeria in June 2004. Ibadan lies within the lowland humid rainforest zone of Nigeria with latitude/longitude of 7°22'N/3°55'E, at 200 m above sea level. Total annual rainfall ranged from 1150–1500 mm which falls mainly between April and October, with the major peak in June. Higher relative humidity values (80–95%) are recorded during the raining season than the dry season (20–50%). The mean maximum and minimum temperatures are 34 and 24°C respectively. The planting was done in single row plot of 10 m long at spacing of 1 m x 1 m. There were three replicates. Two seeds were planted per stand and later thinned to one, two weeks after sowing. Manual weeding was done as at when due and no fertilizer was applied. Sherper Plus (Cypermetrin + dimethoate) brand of insecticide was applied at the rate of 50 g a. i. ha^{-1} at anthesis and subsequently at two weeks interval for a total of 3 applications to control insect infestation.

Table 1. Geographic characteristics of the three states of pigeon pea collection.

Feature	Oyo		Ondo		Ekiti	
	Max	Min	Max	Min	Max	Min
Latitude (°N)	9.18	7.05	7.77	5.85	8.07	7.27
Longitude (°E)	4.56	2.68	6.03	4.35	6.03	5.81
Rainfall (mm) p.a.	1511	1074	2251	1402	1571	1311
Altitude (m)	521	70	619	2	670	304
Temperature (°C)	32.88	20.58	31.61	20.75	31.63	20.45

At maturity, five representative plants were sampled from each plot and the average of the values were recorded on plot basis. The data collected were number of days to 50% flowering, plant height (length of stem from the ground level to the tip of the tallest branch) (cm), length of the mid-leaflet (cm), width of the mid-leaflet (measured at the widest region) (cm), number of primary branches per plant, number of secondary branches per plant, branching height (length of stem from the ground level to the base of first effective branch), pod length (cm), number of seeds per pod, 100 seed weight (g), pod weight per plant, seed weight per plant.

The data collected were subjected to analysis of variance. Principal component analysis was also carried out using PRINCOMP procedure [12]. Those principal components with eigen values > 1.0 were selected. Correlation values between the original characters and the respective principal components were obtained by multiplying the square root of the eigen value for each component by the eigen vector of each of the characters evaluated. To select the relevant characters, those correlation values = 0.6 were considered as relevant for that principal component [4]. The data were also subjected to K-means non-hierachical clustering analysis.

Results and Discussion

The average performance of the 59 pigeon pea collections are shown in Table 2. The collections varied significantly for all the characters evaluated. Number of days to 50% flowering varied between 82 and 190 days while plant height also differed from 80 to 290 cm. The greatest variation was observed in pod weight per plant as illustrated by the high standard deviation value recorded for this yield parameter. Minimum seed weight was 10.0 g with the maximum value of 161.2 g per plant. The branching height also varied significantly between 10.28 and 152.2 cm (Table 2). Since knowledge of the existing genetic variation of the various yield contributing characters are essential for developing high yielding genotypes [6], the observed variation in this work will enhance the genetic improvement of the crop for any of the characters evaluated.

Table 2. Mean values of the characters evaluated.

Character	Mean	Minimum	Maximum	Standard deviation
Days to 50% flowering	128.90	82.0	190.0	19.06
Mid leaflet length (cm)	6.47	3.0	10.0	1.42
Mid leaflet width (cm)	1.96	1.0	4.0	0.59
Plant height (cm)	215.04	80.0	290.0	37.98
Branching height (cm)	46.62	10.28	152.2	23.54
Primary branches/plant	2.50	2.0	7.0	0.94
Secondary branches/plant	6.05	3.0	15.0	2.45
100 seed weight (g)	10.99	9.04	14.21	0.85
Pod length (cm)	4.83	2.0	7.0	1.06
Seeds per pod	4.25	2.0	7.0	0.86
Pod weight/plant (g)	154.17	30.6	312.5	53.99
Seed weight/plant (g)	64.65	10.0	161.2	30.35

The first four principal components with eigen values greater than 1.0 together accounted for about 68% of the variation among the collections (Table 3). The first principal component (PC1) explained 23% of the variation and was associated mainly with yield parameters (pod and seed weights per plant), mid leaflet length and number of days to 50% flowering. The second principal component (PC2) was responsible for about 17% of the variation and was mainly related to number of seeds per pod and pod length. The third principal component (PC3) contributed about 16% to the total variation and was associated mainly with vegetative characters (plant height and number of secondary branches per plant). Finally, the fourth principal component (PC4) was responsible for about 12% of the total variation. Table 4 shows that higher loadings are attributed to characters such as pod and seed weights per plant, number of days to 50% flowering, mid leaflet length, pod length, number of seeds per pod and number of secondary branches per plant which indicate their importance in delineating the collections. The dispersions of the collections in Fig. 1 show considerable amount of variability, although collections from the same source did not clearly sort out except IITA materials. Collections from IITA are 54, 55, 56, 57 and 56, they sorted out along with three other collections: 20, 59 (Oyo) and 37 (Ondo). They all had negative values for PC1 and PC2, they were short, early maturing and low yielding. Another group that can be identified is made up of 5, 6, 12, 9, 52, 4 and 42 which were all collected from Oyo State, except 52 which was from Ondo State. Principal components 1 and 2, however, only captured about 40% of the total variation among the collections (Table 3). When the data were subjected to K-means clustering analysis, the results obtained are shown in Tables 5 and 6.

Table 3. Eigen value and variability explained by each component.

Principal component	Eigen value	Variance (%)	Cumulative
1	2.79	23.29	23.29
2	2.06	17.20	40.48
3	1.91	15.92	56.40
4	1.39	11.62	68.02

Table 4. Correlation coefficients of each characteristic with respect to its principal component (PC).

Character	PC1	PC2	PC3	PC4
Days to 50% flowering	0.62[1]	0.01	0.52	-0.17
Mid leaflet length (cm)	-0.63[1]	0.04	0.53	0.37
Mid leaflet width (cm)	-0.58	-0.26	0.47	0.37
Plant height (cm)	0.56	-0.04	0.61[1]	0.01
Branching height (cm)	0.30	-0.25	0.43	-0.56
Primary branches/plant	0.38	-0.11	0.06	0.58
Secondary branches/plant	0.03	-0.36	0.60[1]	-0.56
100 seed weight (g)	0.04	0.36	0.30	0.43
Pod length (cm)	0.44	0.79[1]	0.11	0.03
Seeds per pod	0.27	0.82[1]	0.09	0.07
Pod weight/plant (g)	0.67[1]	-0.47	-0.25	0.22
Seed weight/plant (g)	0.65[1]	-0.39	-0.21	0.44

[1]Relevant characteristics when explaining the components.

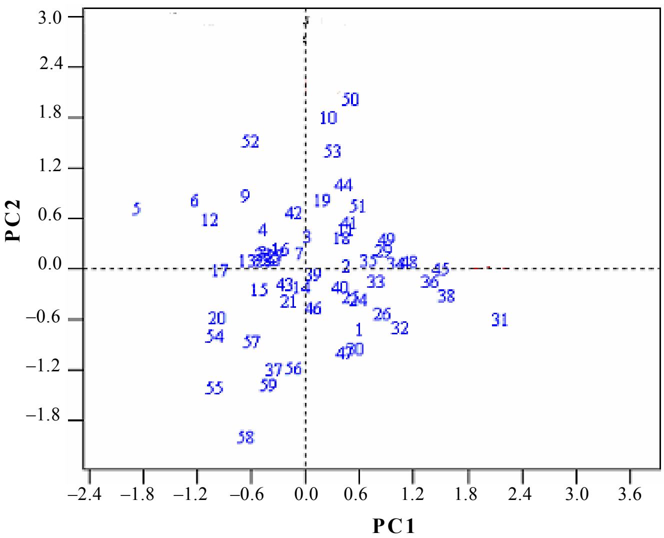

Figure 1. Dispersion diagram of the collections between the first and second principal components.

Table 5. Mean characteristics of each of the four clusters.

Cluster	1	2	3	4
Member	22	21	8	8
Average values for each cluster				
Days to 50% flowering	130.03	136.52	137.79	96.88
Mid leaflet length (cm)	6.93	6.23	5.63	6.66
Mid leaflet width (cm)	2.04	1.86	1.77	2.17
Plant height (cm)	216.91	226.06	286.83	159.17
Branching height (cm)	45.26	55.47	42.53	31.22
Primary branches/plant	2.43	2.60	2.79	2.42
Secondary branches/plant	6.33	5.90	6.33	5.38
100 seed weight (g)	11.11	11.10	10.58	10.87
Pod length (cm)	5.09	4.75	5.10	4.03
Seeds per pod	4.44	4.17	4.33	3.88
Pod weight/plant (g)	102.57	177.14	241.74	148.23
Seed weight/plant (g)	43.05	67.32	116.97	64.70

Table 5 shows that the pigeon pea collections were grouped into 4 clusters using K-means non-hierarchical clustering. Cluster 1 was formed by 22 collections, nine of which were collected from Ondo, 7 from Oyo and 6 from Ekiti states (Tables 5 and 6). The cluster contained tall, late maturing and low yielding collections with the lowest pod and seed weights per plant (Tables 5 and 6). There were 21 members in Cluster 2, made up of collections from each of the 3 states as shown in Table 6. Members are tall, late maturing and low yielding with the highest value for branching height (Table 5). Cluster 3 comprised of 8 collections, 5 of which were from Ondo and 3 from Oyo states. Members of this cluster had the highest number of days to 50% flowering, plant height and pod and seed weights per plant with relatively well filled long pods (Tables 5 and 6). Candidate future varieties could be selected from this cluster with good characteristics. Finally Cluster 4 consisted of 8 collections, 5 of which were from IITA, 1 from Ondo and 2 from Oyo States. Members of this cluster are early maturing, short and low yielding. Results from Table 7 show that Clusters 1 and 2 are the most closely related with the least inter-cluster distance of 79.88 units. As most of the collections (73%) from the three states fall into these two clusters (Tables 5 and 6), the result is an indication of low level of genetic diversity among the collections from the three states. Low level of genetic diversity among cultivated pigeon pea has been reported previously [5, 14]. The level of genetic variability can be enhanced by the application of artificial mutation since mutation breeding is a viable option for creating useful genetic variability. The genetic base may also be improved through introduction from other places particularly from India where there is a considerable genetic variability for this crop [15]. It was also observed that most of the local collections from the three states were late maturing compared with IITA materials. The accessions from IITA could be recombined with selections from cluster 3 to develop well adapted, early maturing and high yielding pigeon pea genotypes. It is anticipated that through mutation breeding, introduction, recombination and selection, improved varieties which are more productive than those currently grown by farmers can be developed.

Table 6. Sources of members of each of the four clusters.

Cluster	Members	Source of collection
1	1, 2, 26, 31, 34, 37, 39, 45, 47 = 9	Ondo
	14, 16, 20, 21, 22, 38, 59 = 7	Oyo
	24, 25, 32, 33, 36, 48 = 6	Ekiti
2	3, 4, 7, 8, 9, 11, 12, 13, 15, 23, 27 = 11	Oyo
	18, 28, 35, 42, 43, 46 = 6	Ondo
	41, 49, 51 = 3	Ekiti
	53 = 1	NAGRAB
3	17, 19, 44, 50, 52 = 5	Ondo
	5, 6, 10 = 3	Oyo
4	54, 55, 56, 57, 58 = 5	IITA
	40 = 1	Ondo
	29, 30 = 2	Oyo

Table 7. Intercluster distance, according to K-mean clustering analysis.

Cluster	1	2	3	4
1	-			
2	79.88	-		
3	159.00	83.21	-	
4	84.77	86.48	138.98	-

Acknowledgement

The International Institute of Tropical Agriculture, and National Center for Genetic Resources and Biotechnology, both in Ibadan, are gratefully acknowledged for providing some of the seeds. I am grateful to Miss R. B. Olowoyo and Mr. B. Idowu for their technical assistance.

References

[1]Ezueh, M. I. 1977. Cultivation and utilization of minor food legumes in Nigeria. Tropical Grain Legume Bulletin **10**:28–32.

[2]FAO 1988. Tropical forage legumes. In Akerman, P. J., Cameron, D. G. and Riveros, F. (eds). Plant Production and Protection Series No. 2. Food and Agriculture Organization of the United Nations (FAO), Rome, pp. 539–547.

[3]Kimani, P. M. 2000. Pigeon pea breeding. Objectives, experiences and strategies for Eastern Africa. In Silim, S. N., Mergeal, G. and Kimani, A. G. (eds). Pigeon Pea. Status and Potential in Eastern and Southern Africa. Gembloux Agricultural University and International Crop Research Institute for Semi-Arid Tropics, pp. 21–31.

[4]Matus, I., Gonzales, M. I. and Pozo, A. 1999. Evaluation of phenotypic variation in a Chilean collection of garlic (*Allium sativum* L.) clones using multivariate analysis. Plant Genetic Resources Newsletter **117**: 31–36.

[5]Nadimpalli, R. G., Jarret, R. L., Phatak, S. C. and Kochert, G. 1994. Phylogenetic relationships of the pigeon pea (*Cajanus cajan*) based on nuclear restriction fragment length polymorphism. Genome **36**:216–223.

[6]Natarajan, C., Thiyagarajan, K. and Ayyamperumal, A. 1990. Genetic variability, correlation and path analysis in pigeon pea. Madras Agricultural Journal **77**(9):378–381.

[7]Odeny, D. A. 2000. Inheritance of resistance to fusarium wilt in pigeon pea. In Silim, S. N., Mergeal, G. and Kimani, A. G. (eds). Pigeon Pea. Status and Potential in Eastern and Southern Africa. Gembloux Agricultural University and International Crop Research Institute for Semi-Arid Tropics, pp. 43–47.

[8]Oyenuga, V. A. 1967. The grain crops: The pulses. Agriculture in Nigeria, An Introduction. FAO, Rome, pp. 199-213.

[9]Patel, N. R., Mehta, A. N. and Shekh, A. M. 1997. Effects of sowing dates and row spacing on phenology and yield of two diverse genotypes of pigeon pea (*Cajanus cajan*). Indian Journal of Agricultural Sciences **67**(4):153–156.

[10]Ratnaparkhe, M. B., Gupta, V. S., Ven Murthy, M. R. and Ranjekar, P. K. 1995. Genetic fingerprinting of pigeon pea [*Cajanus cajan*) (L.) Millsp] and its wild relatives using RAPD Markers. Theoretical and Applied Genetics **91**:893–898.

[11]Saka, J. O., Ajibade, S. R., Adeniyan, O. N., Olowoyo, R. B. and Ogunbodede, B. A. 2004. Survey of under-utilized grain legume production systems in south-west agricultural zone of Nigeria. Journal of Agriculture and Food Information **6**(2/3):93–108.

[12]SAS 1997. User's Guide. SAS Institute, Cary, NC.

[13]Togun, A. O. and Tayo, T. O. 1998. The response of pigeon pea (*Cajanus cajan* (L.) Millsp) to sowing time in Ibadan, south-west Nigeria. Nigerian Journal of Science **32**(1):33–42.

[14]Van der Maessen, L. J. G. 1980. Pigeon pea: Origin, history, evolution and taxonomy. In Nene, N. L., Hall. S. D. and Sheila, V. K. (eds). The Pigeon Pea. Cab International Press, Cambridge, London.

[15]Wasike, S., Okori, P. and Rubaihayo, P. R. 2005. Genetic variability and relatedness of the Asian and African pigeon pea as revealed by AFLP. African Journal of Biotechnology **4**(11):1228–1233.