Evaluation and heritability studies of local Lima bean (*Phaseolus lunatus L.*) cultivars from south-west Nigeria

Evaluación y estudios de heredabilidad de algunos cultivares locales de *Phaseolus lunatus* (L.) del sudoeste de Nigeria

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ABSTRACT

Seven local Lima bean cultivars were evaluated at Ile-Ife in the humid rainforest environment of south western Nigeria for two years. A randomized complete block design with three replications was used each year. Data were subjected to analysis of variance, Pearson correlation and stepwise multiple regression analyses. Heritability estimates of 10 agronomic characters evaluated were also determined. Significant year and cultivar effects were observed for most of the characters. Seed yield ha-^{1} varied from 289.14 to 1358.74 kg. Only two cultivars had seed yield above 1000 kg ha-^{1}, others yielded poorly. Seed yield had positive and significant correlation with branching height, number of seeds per pod, 100- seed weight and inter-nodal length. Results of stepwise multiple regression analysis showed that pod weight per plant, 100-seed weight and pod length were the main seed yield components in Lima bean and together they accounted for 98% of the variability. One hundred seed weight also had the highest broad sense heritability estimate of 98%. Characters such as pod length, mid leaflet surface area, pod weight per plant and inter-nodal length were moderately heritable. The implications of these findings in lima bean improvement were discussed.

Key words: Lima beans, evaluation, correlation, heritability estimates, seed yield.

RESUMEN

Se evaluaron siete cultivares locales de *Phaseolus lunatus* (L.) en ambiente de selva lluviosa húmeda del sudoeste de Nigeria durante dos años. Se utilizó un diseño de bloques completos al azar con tres repeticiones en cada año. Los datos evaluados se analizaron mediante el análisis de varianza y los análisis de correlación de Pearson y de regresión múltiple paso a paso. También se determinaron las estimaciones de heredabilidad de 10 caracteres agronómicos. Se observaron efectos significativos para la interacción años x cultivar para la mayoría de los caracteres. El rendimiento de semilla/ha varió de 289,14 a 1358,74 kg. Solamente dos cultivares tuvieron rendimientos de semilla superiores a 1000 kg/ha, otros tuvieron bajos rendimientos. El rendimiento de semillas tuvo una correlación positiva y significativa con la altura de ramificación, número de semillas por vaina, peso de 100 semillas y la longitud inter-nodal. Los resultados del análisis de regresión múltiple paso a paso mostraron que el peso de vainas por planta, peso de 100 semillas y la longitud de la vaina fueron los factores más determinantes del rendimiento de semillas en *P. lunatus* y juntos explicaron el 98% de la variabilidad. Los caracteres tales como longitud de la vaina, área foliar media, peso de vainas por planta y longitud inter-nodal fueron moderadamente heredables. Se discuten las implicaciones de estos resultados en el mejoramiento de *P. lunatus*.

Palabras claves: *Phaseolus lunatus*, rendimiento de semilla, caracteres agronómicos, correlación, heredabilidad

INTRODUCTION

Lima bean (*Phaseolus lunatus* L.) originated in tropical America. Details of the origin and distributions of this crop have been described by various authors (Kay, 1979; Rachie *et al*., 1980; Lyman *et al*., 1985; Smart 1990). Following introduction to the various ecological zones, Lima bean underwent considerable adaptation and hybridization to produce the various local strains that exist in the different regions of America, Europe, Asia and Africa (Esquivel *et al*., 1990; Nwokolo, 1996). The USA is the world largest producer of lima beans followed by Malagasy and Peru.

In Nigeria, Lima bean is cultivated mainly for the dry seeds. Like other grain legumes, it is an important source of vegetable protein and it also improves soil fertility. It is well adapted to the humid rainforest environment of southern Nigeria. Despite the great potential of this crop, it is highly under-utilized in the country and it has not received much attention in term of crop improvement and so local cultivars are still being grown by the farmers. Lima bean has not received the benefit of intensive research programme as devoted to cowpea and soybean (Lyman *et al*., 1985). It is cultivated in only about 4% land area devoted to grain legumes production in south west Nigeria with no improved technology targeted towards the production of the crop and so yield is low. It is usually intercropped with cassava, maize, yam, cocoyam and pepper. It is mainly produced for consumption as only about 35% of the grain produced is sold (Saka *et al.,* 2004). There is therefore, urgent need for the improvement of this crop.

For the improvement of any crop, knowledge of the relations among various characters with seed yield is essential in order to find appropriate selection criteria. Also type of selection to be done and progress from selection for a particular character depends in part on the magnitude of heritability estimate. This is because the expected response under selection is a function of heritability, variation and selection intensity. Quite often characters are correlated and selection for one character may lead to negative or positive response in the other character. This response can be predicted if the correlation and the heritability of the characters are known (Morakinyo, 1996). The objectives of this work therefore, were to evaluate the performance of seven local lima bean cultivars from south-west Nigeria and to study the correlation coefficients among 10 agronomic characters of the crop and their heritability as an aid to improving the crop.

MATERIALS AND METHODS

Seven local Lima bean cultivars were evaluated for seed yield and nine other agronomic characters at Ile-Ife, Nigeria for two years (2005 and 2006). Ile-Ife lies within the humid rainforest zone of south west Nigeria (7◦ 22′ N, 3◦ 33′ E, 286 m above sea level), with mean annual rainfall of 1200 mm. Total annual rainfall in 2005 and 2006 at this site are 1190.7 mm and 1276.2 mm respectively.

The seeds were sown in June of each year under rain fed conditions. The source of the seven Lima bean local cultivars evaluated are presented in Table 1. A randomized complete block design with three replications was used each year. A plot was made up of five rows, 4 m long at spacing of 60 x 40 cm. Two seeds were planted per hole and thinned to one three weeks after seedling emergence. The plants were staked. Manual weeding was done as at when due, no herbicide was applied. Karate (Lambda-cyhalothrin) brand of insecticide was applied at the rate of 2ml/litre three times, once at 50% flowering and twice at podding to control insect attack.

Table 1. Source of the seven lima bean (*Phaseolus lunatus* L.) cultivars evaluated at Ile-Ife, Nigeria in 2005 and 2006.

Cultivars	Seed colour	Source (State)
NSWP83	Grey	Ondo
NSWP9	Brown	Ekiti
NSWP52	White	Ekiti
NSWP51	Speckled brown	Oyo
NSWP89	Brown	Ondo
NSWP46	Brown	Oyo
NSWP53	Brown	Ekiti

To reduce border effects, data were recorded only from the three central rows of the five row plots. At maturity, measurement for each trait was carried out on five plants per plot and the mean value used for the analysis. Data collected were: number of days to 50% flowering, mid leaflet surface area (the middle leaflet of the trifoliate leaf), number of main branches per plant at the first effective branch, branching height (length of stem from the ground level to the base of effective branch). Inter-nodal length (distance between the third and the fourth nodes), pod weight per plant, pod length, number of seeds per pod and 100-seed weight. Harvesting of the pods was carried out in December of each of the two years. All pods of the middle two rows of each plot were harvested together, dried and threshed to determine seed yield per plot from which seed yield per hectare was estimated.

The data were subjected to analysis of variance, and means were separated using Duncan Multiple Range test. Pearson correlation and stepwise multiple regression analyses were also carried out to determine the main yield components for Lima bean. Broad sense heritability estimates were calculated

using the variance components derived from the analysis of variance.

RESULTS AND DISCUSSION

The average values of the vegetative and reproductive characters of the lima bean cultivars in 2005 and 2006 are shown in Tables 2 and 3. The cultivars varied significantly for all the characters except for the number of main branches. Cultivar means across years show that branching height varied between 7 and 12 cm, NSWP53 had the highest value while NSWP89 and NSWP46 had the least values. Cultivar NSWP53 had the highest inter-nodal length of 10.15 cm and this was about double the values recorded in cultivars NSWP52 and NSWP46 for which the lowest values were recorded. Mid leaflet surface area also varied between 53 and 72 cm² with NSWP46 having the largest value while NSWP52, NSWP83 and NSWP51 had the lowest values.

Number of days to 50% flowering ranged from 81.67 to 88.50 with NSWPP9 and NSWP46 being earliest and latest to flower respectively. Pod length ranged from 4.5 cm in cultivar NSWP9 to 10.5 cm in NSWP53. Other cultivars were intermediate between the two. Cultivar NSWP83 had the highest number of seeds per pod (3.84) almost twice that recorded in NSWP9 which had the lowest value. All other cultivars were however not significantly different for this trait. High variation among the cultivars was observed for 100 seed weight with cultivar NSWP53 having the highest value of 69.31 g which was more than thrice the value recorded for NSWP9 (21.79 g). Pod weight per plant varied from 16.86 g in NSWP51 to 62.78 g in NSWP53. All the cultivars differed significantly for this trait except NSWP52 and NSWP89. The greatest variation was observed in seed yield which ranged from 289.14 in NSWP51 to 1358.74 kg ha^{-1} in NSWP53. Each cultivar significantly differed from every other cultivar.

The cultivar NSWP53 had the highest grain yield and high values for other characters except mid leaflet surface area. Hence, this cultivar would be incorporated into breeding project for further improvement. Apart from the two cultivars (NSPW83 and NSPW53) which had grain yields of above 1000 kg ha^{-1}, other cultivars were very low yielding for

Table 2. Average values of vegetative characters of seven Lima bean (*Phaseolus lunatus* L.) local cultivars evaluated at Ile-Ife, Nigeria in 2005 and 2006.

	Cultivars †							
Years	NSWP83	NSWP9	NSWP52	NSWP51	NSWP89	NSWP46	NSWP53	YM
	Branches per plant							
2005	4.00	4.00	4.00	4.00	4.67	5.00	3.00	4.09a
2006	3.00	3.00	3.00	2.33	3.00	3.00	3.00	2.91b
CM	3.50	3.50	3.50	3.17	3.84	4.00	3.00	
	Branching height (cm)							
2005	9.00bc	9.00bc	10.33b	13.00a	8.00c	8.50bc	13.00a	10.12a
2006	8.00b	8.00b	8.00b	7.00bc	6.00c	6.50c	11.00a	7.79b
CM	8.50cd	8.50cd	9.17bc	10.00b	7.00e	7.50de	12.00a	
	Inter nodal length (cm)							
2005	7.33bc	7.33bc	6.33bc	9.00a	8.67ab	4.00d	10.83a	7.64
2006	6.17bc	8.50ab	5.00c	8.00ab	7.33abc	5.17c	9.47a	7.09
CM	6.75cd	7.92bc	5.67de	8.50ab	8.00ab	4.59e	10.15a	
	Mid leaflet surface area (cm^2)							
2005	55.00d	69.00b	56.00cd	59.00cd	70.00b	83.00a	64.00c	65.14
2006	53.00c	62.00b	50.00c	50.00c	66.00a	62.00b	53.00c	56.57
CM	54.00e	65.50c	53.00e	54.50e	68.00b	72.00a	58.50b	

† Cultivar means (CM) on the same row followed by different letters are significantly different at 0.05 probability level according to Duncan Multiple Range test.
For each trait, year means (YM) followed by different letters are significantly different at 0.05 probability level according to Duncan Multiple Range test.

Table 3. Average values of the reproductive characters of seven Lima bean (*Phaseolus lunatus* L.) local cultivars evaluated at Ile-Ife, Nigeria in 2005 and 2006.

	Cultivars †							
Years	NSWP83	NSWP9	NSWP52	NSWP51	NSWP89	NSWP46	NSWP53	YM
	Days to 50% flowering							
2005	85.00b	83.33b	84.00b	83.00b	90.00a	89.67b	85.00b	85.71a
2006	82.67b	80.00c	83.33b	82.00b	86.00a	87.33a	86.00a	83.91b
CM	83.84bc	81.67d	83.67bc	82.50cd	88.00a	88.50a	85.50b	
	Pod length (cm)							
2005	6.50bc	5.00c	7.00b	6.00bc	7.00b	7.00b	11.00a	7.07a
2006	6.00b	4.00c	6.00b	5.50bc	5.00bc	6.20b	10.00a	6.10b
CM	6.25b	4.50c	6.50b	5.75b	6.00b	6.60b	10.50a	
	Seeds per pod							
2005	4.00a	2.00b	3.00ab	3.00ab	3.00ab	4.00a	3.00ab	3.14a
2006	3.67a	2.00c	2.00c	2.00c	3.00b	2.67b	3.00b	2.62b
CM	3.84a	2.00c	2.50bc	2.50bc	3.00ab	3.34ab	3.00ab	
	100 seed weight (g)							
2005	28.52c	22.21d	31.46b	28.62c	31.69b	28.66c	71.21a	34.62
2006	25.37d	21.37e	29.90b	26.81cd	30.83b	27.70c	67.40a	32.75
CM	26.95d	21.79e	30.68b	27.72cd	31.26b	28.18d	69.31a	
	Pod weight (g)							
2005	55.77b	23.03e	38.18d	18.06f	43.45c	20.91ef	83.19a	40.08a
2006	61.34a	19.47d	31.92c	15.66e	21.16d	19.55d	42.36b	30.21b
CM	58.56b	21.25d	35.05c	16.86e	32.31c	20.23d	62.78a	
	Seed yield (Kg ha-^{1})							
2005	1112.5b	446.47e	625.80d	302.53g	750.70c	361.50f	1654.09a	750.51a
2006	1059.04b	337.58f	554.33c	275.75g	375.51d	347.78e	1063.39a	573.34b
CM	1085.77b	392.03e	590.07c	289.14g	563.11d	354.64f	1358.74a	

† Cultivar means (CM) on the same row followed by different letters are significantly different at 0.05 probability level according to Duncan Multiple Range test.
For each trait, year means (YM) followed by different letters are significantly different at 0.05 probability level according to Duncan Multiple Range test.

profitable farming. Rachie *et al*., (1980) reported that Lima bean could produce dry seed yield in excess of 2000 kg ha-^{1}, but it was yet to realize its potential in the tropics. In a socio-economic survey of production systems of some under-utilized grain legumes including Lima bean in south-west Nigeria, low grain yields were recorded by the farmers despite reported low incidence of diseases and insect pests. Some of the reasons adduced for the low yield include lack of improved varieties, lack of agronomic practices targeted towards the production of the crop, high cost of labour and low market demand (Saka *et al*., 2004). Lima bean, like other grain legumes is rich in protein, carbohydrate and some minerals, although it also contains some anti-nutritional factors (Apata and Ologhobo, 1994; Fasoyiro *et al*., 2006). There is therefore a need for the improvement of this crop so as to encourage its cultivation by farmers.

Significant year effect was observed for all the characters evaluated except for number of seeds per pod. The results indicate that changes in environmental conditions between the two years influenced the performance of the cultivars (Tables 2 and 3). The cultivars flowered earlier in 2006 with an average value of 83.91 compared with 85.71 recorded in 2005. Higher values were also recorded for all other characters when evaluated in 2005 (Tables 2 and 3). For example average grain yield in 2005 was 750.51 kg ha-^{1} as against 573.34 kg ha-^{1} in 2006. The environmental conditions of 2005 were probably more favourable for Lima bean production. Total rainfall received in 2005 was 1190.7 mm which was

less than what was experienced in 2006 (1276.2 mm). The reduced rainfall received in 2005 could result in less incidence of diseases. The effect of year x cultivar interaction was significant on four characters, branching height, mid leaflet surface area, pod weight per plant and seed yield ha-^{1}. In 2005, NSWP51 had one of the highest value (13.0 cm) for branching height while in 2006, it was rated among the shortest with a value of 7.0 cm. Cultivar NSWP46 had the largest mid leaflet surface area of 83.0 cm^{2} while NSWP83 had the lowest value in 2005. In 2006 however, NSWP89 had the largest mid leaf surface area of 66.0 cm^{2} while NSWP52 had the lowest value of 50.0 cm. In 2005, Cultivar NSWP53 had the highest pod weight of 83.19 g per plant but in 2006 NSWP83 had the highest value of 61.34 g. Also in both years, NSWP53 and NSWP83 had the best seed yields with NSWP51 having the least, however, in 2005, NSWP89 was rated third in seed yield while in 2006 it was ranked fourth using Duncan multiple range test (Tables 2 and 3).

The correlation coefficients of the ten characters of Lima bean evaluated are shown in Table 4. Number of days to 50% flowering was significantly correlated with number of main branches per plant, mid leaflet surface area, pod length and number of seeds per pod. The results indicate that the longer the number of days to flowering the higher the values of the latter mentioned characters. Although number of days to 50% flowering had positive correlation with seed yield, it was not significant. Ariyo (1995) reported positive significant genotypic correlation between soybean seed yield and days to maturity, but the phenotypic correlation was not significant. The vegetative characters such as number of branches per plant, branching height and mid leaflet surface area were significantly correlated with one another. Inter nodal length was however only significantly correlated with branching height. Branching height was significantly correlated with pod length. Branching height and inter nodal length had positive and significant correlation with 100 seed weight and pod weight per plant.

Pod length, number of seeds per pod, 100 seed weight and pod weight per plant were all significantly and positively correlated with one another except that the correlation between 100 seed weight and number of seeds per pod was not significant. Seed yield ha-^{1} had significant and positive correlations with branching height, pod

Table 4. Pearson correlation coefficients of 10 agronomic characters of seven Lima bean (*Phaseolus lunatus* L.) local cultivars evaluated at Ile-Ife, Nigeria in 2005 and 2006.

Characters	50% Flowering	Branches per plant	Branching height	Inter-nodal length	Leaflet surface area	Pod length	Seeds per pod	100 seed weight	Pod weight per plant
Branches per plant	0.62**	-							
Branching height	0.03	0.37*	-						
Inter-nodal length	-0.27	-0.29	0.39*	-					
Leaf-let surface area	0.60**	0.54**	0.01**	-0.18	-				
Pod length	0.44**	0.27	0.69**	0.27	0.06	-			
Seeds per pod	0.49**	0.53**	0.29	0.21	0.28	0.41**	-		
100 seed weight	0.21	-0.10	0.58**	0.50**	-0.08	0.88**	0.13	-	
Pod weight per plant	0.10	0.02	0.44**	0.32*	-0.15	0.66**	0.36*	0.61**	-
Seed yield per ha	0.10	-0.05	0.46**	0.40**	-0.19	0.71**	0.31*	0.73**	0.98**

*, **, significant at 0.05 and 0.01 probability levels, respectively

weight, pod length, number of seeds per pod, 100-seed weight and inter-nodal length. This result suggests that long pods, well filled with big seeds could significantly contribute to improved seed yield in Lima bean. Also the longer the branching height and the inter-nodal length which are an indication of the length or height of the plant the higher the seed yield in this crop.

The results of the stepwise multiple regression showed that three characters, (pod weight per plant, 100-seed weight and pod length) out of the 10 characters evaluated were the main seed yield components (Data not shown). The three characters together accounted for 98% of the variability in seed yield. Pod weight per plant alone was responsible for 95% of the total variation, this is understandable as pod weight per plant is a function of number of pods per plant, pod length and seed size. One hundred seed weight and pod length, however, only explained 3% and 0.004% of the variability respectively.

The heritability estimates of the characters are shown in Table 5. Out of all the characters, 100 seed weight had the highest broad sense heritability estimate of 98%. The result indicates that 100-seed weight is not significantly affected by changes in environmental conditions. In a study involving cowpea, 100-seed weight was also reported to have high broad sense heritability estimate of 96% (Ajibade and Morakinyo, 2000). Although, pod weight per plant was the main determinant factor of seed yield, it was only moderately heritable. Therefore, 100-seed weight is a better indicator of seed yield in Lima bean; it could then be used as a selection criterion for higher seed yield. Seed yield could also be selected for directly since it had moderate heritability estimate of 64%. Characters such as pod length, mid leaflet surface area, pod weight and inter nodal length were moderately heritable. Number of main branches and seeds per pod however, had low heritability estimates.

Table 5. Broad sense heritability estimates of 10 agronomic characters of seven Lima bean (*Phaseolus lunatus* L.) local cultivars evaluated at Ile-Ife, Nigeria in 2005 and 2006.

Characters	Heritability estimates (H_b)
Days to 50% flowering	0.37
Branches per plant	0.002
Branching height	0.22
Inter nodal length	0.33
Mid leaflet surface area	0.40
Pod length	0.56
Seeds per pod	0.14
100 seed weight	0.98
Pod weight per plant	0.38
Seed yield kg ha-^{1}	0.64

CONCLUSION

In this study, two lima beans cultivars were identified to produce seed of above 1000 kg h-^{1} while others were low yielding. Results of stepwise multiple regression analysis showed that pod weight per plant, 100 seed weight and pod length were the main determinant factors of seed yield in lima bean. One hundred seed weight also had the highest broad sense heritability. It is therefore, a good indicator of seed yield in lima bean. The results of this study will provide the basis for lima beans improvement which has been neglected over time.

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