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Evaluation of growth and yield components of Lima beans (*Phaseolus lunatus* L.)

Agbeleye O. A., Adebayo A. K., Olayinka R. B. and Ayoola O. T.
Grain Legumes Improvement Programme, Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan.
**Corresponding author email: agbeleye.adeola@gmail.com*

Abstract

Lima bean (*Phaseolus lunatus* L.) is an underutilized legume with potentials for alleviating food insecurity. This study was carried out to analyse genetic diversity among seventeen accessions of lima bean (*Phaseolus lunatus* L.) collected from SouthWest Nigeria. The experiment was carried out at the research field of the Institute of Agricultural Research and Training using a randomized complete block design with three replications. Data were collected on seven quantitative traits and subjected to analysis of variance. Correlation analysis was also carried out to obtain information on associations among the traits studied. Highly significant variations were observed for growth and yield components. NSWP 51A was the earliest to emerge at 6 days after planting. Days to budding, 50% flowering and podding ranged between 66-86 days, 77-102 days and 73-103 days respectively. NSWP 27 was the earliest to attain maturity at 118.67 days. Days to budding had positive and highly significant correlation with days to 50% flowering, pod set and days to maturity. Variations observed among the genotypes studied indicate the amenability of Lima beans to genetic improvement.

Keywords: Genetic diversity, *Phaseolus lunatus*, Underutilized legumes, Yield components

Introduction

Food and nutrition security continue to be a challenge due to increasing global population. In Africa, food insecurity is exacerbated by climate change, wars and political instability among other factors. Dependence on a few cereal crops and two model legumes in spite of more than 350,000 plant species of which 80,000 are edible (Fuleky, 2006) adds to the problem. Underutilized legumes have potentials for contributing to food security if their salient advantages are exploited.

One of the underutilized legumes is Lima bean (*Phaseolus lunatus* L.). Lima bean originated from Peru (Oraka and Okoye, 2017). It is an herbaceous species with a short annual or short-lived perennial life cycle (Penha *et al*., 2017). Lima bean is the second most important species after *Phaseolus vulgaris* in the genus *Phaseolus* (Maquet *et al*., 1999). It is usually intercropped with vegetables in the tropics or planted after maize harvest in mixed cropping systems (Ibeawuchi *et al*., 2007). Lima bean is predominantly a selfer but outcrossing rates as high as 38.1% has been reported (Penha *et al.,* 2017).

Lima bean is an important source of protein for rural populations in South America and Africa (Lioi *et al*., 1998). In Nigeria, it remains an underutilized legume cultivated for its dry seeds and soil fertility restoration attributes (Ibeawuchi, 2007). No variety of the crop has been released hence only landraces in gene banks and farmers' hands are available. With little or no improvement, lima bean remains a subsistence crop as only 35% of harvested grains are sold (Saka *et al*., 2004).

Like other neglected and underutilised species (NUS); high content of anti-nutritional factors is observed in lima beans but these can be easily reduced by processing (Oraka and Okoye. 2017; Farinde *et al*., 2018). High cyanoglucosides have also been reported in young leaves and seeds of lima beams (Ballhorn *et al*., 2005). Genetic diversity is important for the success of any breeding program (Ali *et al*., 2007). Evaluation of germplasm is thus a prerequisite as crop improvement is impossible without variation in target traits. To harness the potentials of lima bean and prevent its extinction, there is need for renewed research interests. There is abundant literature on lima beans on the effects of processing methods (Farinde *et al*., 2018; Seidu *et al*., 2018), proximate, anti- nutritional, mineral and amino acid composition (Oraka and Okoye, 2017; Soetan, 2018; Ishaya and Aletor, 2019), digestibility of lima meals (Falaye *et al*., 2014; Aremu *et al*., 2016) as well as its supplementation in animal feeds (Aliu and Odeh, 2019). Using serological tests, Mamman *et al*., (2018) identified four viruses affecting lima bean.

However, very few studies exist on the agronomy, morphological diversity, breeding and improvement of the crop in Nigeria. Akande and Balogun (2007) studied ten agronomic traits in seven local lima bean genotypes and identified two genotypes with yield above 1000 Kg ha^{-1}. Also, in their study, pod weight per plant, 100-seed weight and pod length were the main seed yield components as they accounted for 98% of observed variation. Porbeni *et al.* (2018) evaluated 24 accessions of seven miscellaneous legumes which included just one Lima bean accession. Eboibi *et al.* (2018) investigated the influence of organic amendment on five lima bean accessions observing that improvement of soil nutrients by compost manure had a significantly positive effect on plant girth, number of leaves, mean number of flower, total fresh and dry weight of the accessions.

It is therefore evident that, there is need for information on the yield potentials of Lima bean as well as an understanding of traits contributing directly or indirectly to yield. Hence, the objectives of this study were to obtain information on genetic variation for growth and yield-related characters among seventeen lima bean accessions; and to assess relationship among traits of the accessions with a view to providing plant breeders, information and direction on traits of interest for Lima bean improvement.

Materials and Methods

A field experiment was carried out during the rainy season of 2016 at the Institute of Agricultural Research and Training (IAR&T) research field, Ibadan (latitude at 07° 22'N, 3° 50'E) in the derived savannah/transition agro-ecology of South-West Nigeria with mean altitude of 122m above sea level, annual precipitation of 1220mm and mean temperature of 26°C. Land preparation was carried out by manual slashing of the site followed by mechanical ploughing and harrowing. Seventeen lima bean accessions collected from the germplasm collection of IAR&T (Table 1) were used in the study.

The experiment was laid out in a randomised complete block design replicated three times. The site was marked out into different plots; plot size was 4m x 3m ($12m^2$) with 1m x 1m inter- and intra-row spacing. Each plot was separated by a 1m alley. Two seeds were planted per hole and thinned down to one two weeks after seedling emergence. Stakes were provided one week after seedling emergence.

Table 1. Source and seed coat colour of seventeen Lima bean accessions evaluated at IAR&T, Ibadan during the 2016 cropping season

S/N	Accession	Seed coat colour	Source of collection
1	NSWP 09	Brown	Ado-Ekiti
2	NSWP 27	Grey	Ita-Ogbolu
3	NSWP 51A	Cream	Ado-Ekiti
4	NSWP 52	White	Ado-Ekiti
5	NSWP 53	Mottled Cream	Ado-Ekiti
6	NSWP 62	Dark Brown	Ondo (Serafu)
7	NSWP 64	Cream	Olomide market
8	NSWP 89	Dark Brown	Ita-Ogbolu
9	NSWP 89A	Mottled brown	Ita-Ogbolu
10	NSWP 92	Brown	Ibadan
11	NSWP 92B	Brown	Ibadan
12	NSWP 94	Brown	Ibadan
13	NSWP 95A	Brown	Ibadan
14	NSWP 95B	Black	Ibadan
15	NSWP 97B	Brown	Ibadan
16	NSWP 98	Brown	Ibadan
17	NSWP 99A	Mottled brown	Ibadan

Insect pests were controlled with three applications of Lambda cyhalothrin (Karate; 2ml/litre) once at flowering and twice at podding. Weeding was done manually as and when due throughout the period of the experimental. Data were collected on days to emergence, bud initiation, 50% flowering, days to pod set, days to maturity, pod length (cm) and number of seeds/pod from the two middle rows. All data were subjected to analysis of variance and Pearson's correlation test using Statistical Tool for Agricultural Research (STAR) © 2013. Significant means were separated by Tukey's Honest Significant Test (HSD).

Results and Discussions

Highly significant differences were observed for all measured traits in this study indicating genetic variability for growth and yield components (Table 2). Days to emergence ranged between 6 and 11 days with a mean of 9.5 days. Earliest number of days to emergence was observed in NWSP 51A (6 days) while NSWP 09 took the longest time to emerge (11 days). Number of days to emergence is an important trait in crops as it signifies successful germination and early establishment of a crop. Phillips (1989) opined that fast emergence can reduce root rot in dry beans while Valenciao *et al.* (2004) suggested that prevention of soil crusting and addition of substrate in bean plants sown on flat land accelerates emergence and establishment of common beans. Vigorous, rapid, as well as uniform germination and emergence under diverse environmental conditions is a desirable attribute for seedling growth and, ultimately, grain yield in food legumes and cereal crops such as bean, rice, wheat, maize (De Ron *et al* ., 2016). These suggest that like other legumes, early emergence in Lima beans is desirable.

Five accessions out of the seventeen have been previously evaluated over a decade ago but at Ile-Ife in the rainforest agroecology of Nigeria (Akande and Balogun, 2007). Similar trends were observed for some of the traits. Days to budding varied significantly among the accessions with NSWP 94 budding at 66 days and the latest accession to bud was NSWP51A although this was similar to eight other accessions. Four accessions reached 50% flowering at an average of 76 days. The latest accession to attain 50% flowering was NSWP 62 (103 days). This is similar to the report of Akande and Balogun (2007) in which days to 50% flowering ranged between 81.67 and 88.50. The earliest flowering in their study was NSWPP09 (81.67 days), the accession attained 50% flowering at 89.67 days in our study. Pod set was between 73 and 90 days in most accessions. Earliest number of days to podding was observed in NSWP 95A (73 days) and NSWP 95B (75 days) while the latest was NSWP51A (104 days). Pod length varied significantly among the

Table 2. Means of growth parameters of seventeen lima bean accessions evaluated in Ibadan during 2016 cropping season

Accessions	DTE	DTB	50%F	DTP	DTM	PodLT	SPP
NSWP 09	10.67[a]	84.00[ab]	89.67[abcd]	90.00[abcd]	121.67[ab]	7.08[ab]	3.50[a]
NSWP 27	8.67[ab]	80.00[abcd]	95.67[abcd]	96.00[abc]	118.67[b]	6.33[ab]	3.43[ab]
NSWP 51A	6.33[c]	86.00[a]	101.33[ab]	103.67[a]	127.33[a]	7.58[ab]	2.42[bc]
NSWP 52	10.00[a]	81.33[abc]	90.67[abcd]	88.67[abcd]	123.33[ab]	6.93[ab]	3.00[abc]
NSWP 53	9.67[a]	77.67[abcd]	89.00[abcd]	87.00[abcd]	123.33[ab]	6.77[ab]	2.92[abc]
NSWP 62	10.00[a]	80.67[abc]	102.67[a]	102.67[ab]	120.33[ab]	6.51[ab]	3.10[abc]
NSWP 64	10.00[a]	78.33[abcd]	99.33[abc]	91.00[abcd]	120.33[ab]	7.37[ab]	3.27[abc]
NSWP 89	7.33[bc]	70.33[bcd]	77.33[d]	76.67[cd]	119.00[b]	7.54[ab]	3.33[abc]
NSWP 89A	10.00a	74.33[abcd]	83.00[bcd]	80.00[cd]	118.67[b]	7.46[ab]	3.18[abc]
NSWP 92	10.33[a]	70.67[bcd]	83.67[abcd]	82.67[bcd]	120.33[ab]	5.99[ab]	3.02[abc]
NSWP 92B	8.67[ab]	68.33[cd]	78.67[d]	78.00[cd]	119.67[ab]	7.89[a]	3.67[a]
NSWP 94	9.00[ab]	66.00[d]	77.67[d]	75.67[cd]	120.67[ab]	7.21[ab]	3.25[abc]
NSWP 95A	10.00[a]	67.00[cd]	76.67[d]	73.00[d]	119.67[ab]	7.53[ab]	3.27[abc]
NSWP 95B	10.33[a]	67.00[cd]	80.33[cd]	75.00[d]	118.67[b]	6.91[ab]	3.17[abc]
NSWP 97B	10.00[a]	70.33[bcd]	80.67[cd]	78.00[cd]	120.33[ab]	7.18[ab]	3.27[abc]
NSWP 98	10.00[a]	71.33[bcd]	89.67[abcd]	81.67[cd]	121.33[ab]	5.67[b]	2.33[c]
NSWP 99A	10.33[a]	71.67[abcd]	80.67[cd]	80.00[cd]	120.67[ab]	7.81[a]	2.92[abc]
Mean	9.49	74.41	86.86	84.69	120.82	7.04	3.12
CV%	7.39	6.40	7.26	8.01	2.09	8.89	11.07

Means with same alphabet and in the same column are not significantly different
DTE: days to emergence; DTB: days to budding; 50%F: days to fifty percent flowering; DTP: days to podding; DTM: days to maturity; PodLt: pod length (cm); SPP: number of seeds per pod

accessions studied. Accession NSWP92B (7.89cm) had the longest pod; followed by NSWP99A (7.81cm) while the shortest pod was obtained from NSWP 98 (5.67cm). Significant differences were also observed for number of seeds per pod. Accession NSWP 92B had the highest number of seeds while the lowest was in NSWP 98.

Pearson's correlation showed highly significant (p=0.001; p=0.05) relationships among some of the measured traits (Table 3). Days to emergence had no significant association with any trait. Days to budding was positively correlated with days to 50% flowering and days to maturity. Correlation between days to 50% flowering and days of maturity suggest that there is a strong relationship in stage of growth of plant at which flowers are initiated and time to complete crop life cycle. This observation is also in accordance with the findings of Akinyele and Oseite, 2006. Accessions which reach 50% flowering early also mature faster. This is important for selecting early maturing genotypes. Earliness is an important trait in underutilized legumes as one of the challenges to their production remains long stay in the field. A highly significant and positive correlation (r=0.4) was observed between days to pod setting and days to maturity. However, negative but significant association exist between days to maturity and number of seeds per pod. Expectedly, highly significant correlations were observed between pod length and number of seeds per pod. This is similar to the report of Akande and Balogun (2007). The high number of seeds obtained in NSWP92B could be attributed to the long pods. Since pod length is an important yield component in pulses contributing to the grain yield, this might be the reason for higher number of seeds per pod obtained in NSWP 92B. Therefore, pod length and number of seeds per pod should be considered during breeding for improved lima bean varieties.

Most of the accessions used in this study were brown seeded (Table 1). Information is scarce on the relationship between seed coat colour and anti-nutrients in lima beans although Ajibade *et al*., (2005) reported high anti-nutritional factors in dark-seeded African yam bean (AYB). This research gap

Table 3. Pearson's correlation coefficients of 7 quantitative traits evaluated on Lima bean (*Phaseolus lunatus* L.) accessions planted at Ibadan during the 2016 cropping season.

	DTB	50%F	DTP	DM	PODLT	SPP
DTE	-0.08	-0.08	-0.16	-0.19	-0.22	-0.04
DTB		0.72***	0.78***	0.36***	0.0004	-0.20
50%F			0.89***	0.32**	-0.19	-0.19
DTP				0.40***	-0.12	-0.16
DM					0.002	-0.33**
PODLT						0.40**

, * significant at 0.01 and 0.001 probability levels, respectively

DTE: Days to emergence; DTB: days to budding; 50%F: Days to fifty percent flowering;

:Days to podding; DTM: days to maturity; PodLt: pod length (cm); SPP: number of seeds per pod should be investigated to assist plant breeders in selection of desirable accessions for improvement of lima beans.

Conclusions

This study established high genetic variation in lima bean accessions. Crosses between accessions with high number of seeds per pod may generate hybrids with higher yields as number of seeds per pod is an important yield component in legumes. Accession NWSP92B with long pods and high number of seeds per pod is suggested as a parent in the improvement of lima beans.

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