Morphological Characterisation and Cyanide Content Determination in *Phaseolus lunatus Linn.* (Lima Beans) Accessions

ABSTRACT

Lima bean (*Phaseolus lunatus* Linn) is one of the important legumes indevelopingcountries. The study was carried out to evaluate the morphological characters and determine the amount of cyanide in lima beans. A total of 15 Lima bean accessions wereobtained from the genebank of GeneticResourceCentre,InternationalInstituteofTropicalAgriculture(IITA)Ibadan, Oyostate,Nigeria and laid in Complete Randomised Design with three replicates. Morphological characters were evaluated based on the descriptors proposed by the International Plant Genetic Resources Institute, while hydrogencyanide(HCN) content was determined using alkalinepicratecolorimetricmethod. Six of the accessions (2005-014, 2006-003A, 2006-003B, 2006-005A, PS-16 and TPI-2429) having best yield, moderate yield and lowest yield were selected for cyanide determination. Result showed that the accessions varied morphologically. The highest yielding accessions were TPI-2429, 2005-014, 2006-003A and 2005-011, while 2006-003B and TPI-178 had moderate yields.Accession 2005-014 had the highest growth characters, followed by 2006-015 and2006-003A whichshowedgoodquality. Lower amounts of cyanide were detected in 2005-014 and PS-16accessions, while2006-003A,2006-003B and 2006-005A accessions did not show cyanide contents. Therefore, TPI-2429, 2006-003A and 2005-011 accessions which showed higher growth and yield characters with no cyanide content could be further improved in breeding of lima beans.

Comment [dh1]: Do not copas from Conclusion. Make a new sentences

Keywords: Lima beans, Cyanide, Morphological traits and Breeding

1.0 INTRODUCTION

Lima bean (*Phaseolus lunatus* L.), also known as 'Butter bean' is one of the under-utilized legumes of the fabaceae family, second most important economical species of the genus Phaseolus which comprises other legumes such as common bean (*P. vulgaris*), scarlet runner bean (*P. coccineus*) and tepary bean (*P.acutifolius*) (Fofana *et al.,* 1999; Adeniran *et al.,* 2013; Soetan and Atanda, 2018; Adebo, 2023). Its origin in tropical America, specifically from Peru, extended to West and Central Africa and well adapted to humid rainforest in the Southern Nigeria (Baudet, 1977; Gutiérrez-Salgado *et al.,* 1995; Akande and Balogun, 2007; Adebo, 2023). Lima bean seeds are good sources of proteins, carbohydrates, fibers and minerals which can overcome the malnutrition problems for people in developing countries (Kathirvel and Kumudha, 2011; Bonita, *et al.,*2020). The composition of amino acid containing phenol in Lima bean stimulate human gastrointestinal digestion (Arora, 2014; Kyerematen, 2015; Salawu, *et al.,* 2019). In

some parts of West Africa, Lima bean is cooked with maize, rice or yam and used for making special soup and stews. Young pods and leaves are mostly taken as vegetables in Ghana and Malawi (Broughton *et al.,* 2002). The Yoruba tribe in Nigeria processed the seed into cakes, puddings and porridge (Akande and Balogun, 2007; Soetan and Atanda, 2018).

The potential uses of lima bean cultivars can be determined on the basis of morphological characterisation which involve measuring of phenotypic traits using standard plant descriptors (CIP/AVDRC/IBPGR, 1982; 2015; Edmund, 2014). Cyanide is an effective cytochrome oxidase inhibitor which interferes with aerobic respiratory system. Acute hydrogen cyanide poisoning could cause difficulties in breathing and result into death (Osuntokun, 1973; Ologhobo, *et al.,* 1984; Montero-Rojas, *et al.,* 2013; Adebo, 2023). Cyanogenic potential varies with respect to maturity, stage of development, genotype and cultivation conditions. Young leaves and seeds of lima bean had high nutritional contents andvaried cyanide compounds such as cyanogenic glucosides and linamarase which have the potential to cause rapid respiration, drop in blood pressure, headache, vomiting and convulsions (Akande and Balogun, 2007; Ballhorn *et al.,* 2008b; Kathirvel and Kumudha, 2011 Heuzé *et al.,* 2013; Andueza-Noh, *et al.,* 2015; Bolarinwa,*et al.,* 2016).

Lima bean (*Phaseolus lunatus* L.) is scarcely available in most Nigerian markets compared to other common legume species such as cowpea (*Vigna unguiculata*), groundnut (*Arachis hypogea*) and bambara groundnut (*Vigna subterranea*). It is underutilized because it has been cultivated and maintained by few traditional farmers over many years, despite its diversity and yield potential. Moreso, young leaves and seeds of some accessions of lima bean with high level of cyanide content can pose great threat to our health. This necessitate the characterisation of promising limabeansaccessions of high yielding and lowercyanide traits. Therefore, this study was carried out to evaluate the morphological characters and ~~determine the amount of cyanide in lima beans.~~

Comment [dh2]: Wrong objective. You did not measure the cyanide content

2.0 MATERIALS AND METHODS

2.1 Seed Collections and Study Location

The Seed of Fifteen accessions of *Phaseolus lunatus* (Lima beans) wereobtained from the genebank of GeneticsResourceCentre,InternationalInstituteofTropicalAgriculture(IITA)Ibadan, Oyostate,Nigeria asshown in Table 1.

Table 1. Sources and collection of *Phaseolus lunatus* accessions

Lima Beansaccessions	Sources
2006-003A	**IITA**
2006-015	**IITA**
TPI-2429	**IITA**
TPI-189	**IITA**
TPI-198	**IITA**

118-2	**IITA**
198-3	**IITA**
2006-007	**IITA**
2005-014	**IITA**
2005-011	**IITA**
TPI-178	**IITA**
2006-005A	**IITA**
Ps-16	**IITA**
2005-015	**IITA**
2006-003B	**IITA**

2.2 Experimental Design, Seed Processing and Planting Procedure

The field experiment wascarried out from June to October, 2021 at the research farm of the Department of Botany, University of Ibadan, Nigeria. The experiment was laid out in a complete randomised design with three replicates. Mechanical scarification and planting of the seeds were done using standard procedures. Each accession was planted in bags properlylabeledwiththeaccessionnumberforeasyscoringandevaluation. Theplantswerestaked 3 weeks afterplanting.Agronomic practices such as watering and weeding of the plants were duly carried out.

2.3 Determinationofgrowth and yieldcharactersinLimabeans

Morphological Data were taken at weekly intervals. Growth characters; plant height, petiolelength, number of leaves, leaf length and leaf widths were taken with a meter rule andmanualcounting. Theplantheightmeasurementwastakenfromthesoilleveltotheapexoftheplant.Leafwiththebest appearance is used for the measurement of leaf length and leaf width. The length of the leafwastakenfromthebaseoftheleaftotheapex,whilethewidthwastakenfromthehorizontalmid-pointof theleaf margin.Thenumberof leaveswas donebycountingeachleaf ontheplant stand. The evaluation of theyieldparameters;lengthofpod,numberofpodsperrep,numberofloculesperpod,freshpodweight,numberofseedsperrep,seedlength,seed width,seed thickness,numberofseedsineachpod,pod width, 100 seedweightweredone using the descriptors described by IBPGR, (1982; 2015).

2.4 Determinationof HydrogenCyanide(HCN)

The seeds of Six accessions (2005-014, 2006-003A, 2006-003B, 2006-005A, PS-16 and TPI-2429) were tested for cyanide. Hydrogencyanide(HCN) content was determined using alkalinepicratecolorimetricmethodofBalagopalan*etal*.(1998). Two grams each,of thesamplewasdispersedin50mlofdistilledwaterina25mlconicalflask.Analkalinepicratepaper was hung overthesamplemixtureandtheblankintheirrespectiveflasks.Thesetsupwereincubated overnight and each

picrate paper was eluted or dipped into 60ml of distilled water. A standardcyanide solution is prepared and diluted to a required solution. The absorbance of the elutedsolutionswasmeasuredwithcolorimeterat540nmwavelengthwith thereagentblankat zero.

Thecyanidecontentis determinedbytheformulashownbelow.

HCNmg/kg=$^{1000}\cdot\frac{au}{w}\cdot C\cdot\frac{D}{as}$

WhereW=weightof sampleanalyzed;au=absorbanceoftestsample

as=absorbanceofstandardHCNsolution;C=concentrationofthestandard in mg/dD=dilution factor where applicable

2.5 Data analysis of Morphological characters

Morphological data were analysed by Analysis of variance, while differences in means were estimated by Duncan Multiple Range Test. Cluster analysis was conducted by Unweighted Pair Group Methods using Arithmetic averages using Multivariate Statistical Program v.3.1 software. Principal component analysis was also performed to define the role of each character in grouping of the accessions.

3.0 Results

Theresultofgrowthcharactersin15accessions of Lima beans is shown in Table 2. The plant height, petiolelength, number of leaves, leaf length and leaf width varied for all the accessions. All the accessions were significantly different in Plant height and Number of leaves. Accessions 193-3, 015,003b were significantly different, while other accessions were not for leaf length. The PS-16, 2006-015, 2006-003B and 198-3 accessions were significantly higher for leaf width as well as 2005-011 and TPA-198 accessions are also significantly different. PS-16, 198-3, 2006-003A was highly significant, while 2005-011, TPI-178 and TPI-198 are significantly different at $p<0.05$ for Number of leaves.

The result of variations of characters of yield stage of 15 accessions of Lima beans is shown inTable 3. The accessions were varied for no of pods per stand, no of seeds per pod, no of loculesperpod,noofseedsperstand,podlength,podwidth,weightoffreshpod,seedlength,seedwidthandseedthickness.

The 2006-005A, PS-16, 2006-007 and 2006-015 accessions were significantly different, while accessions 2005-015 and TPI-198 are highly significant for number of pod per rep. Accessions TPI-2429, TPI-178, 198-3, TPI-189, 2005-015 and 2006-003B are significantly higher and different. For the Number of locules per pod, TPI-2429, TPI-178,118-2, 198-3, TPI-189, 2005-015 and 2006-003B accessions are highly significant but different at $p<0.01$, while 2006-005A, PS-16, 2006-007, 2006-015 accessions are significantly different at $p<0.05$. Accessions 2005-011, 2006-003A as well as 118-2, TPI-198, 198-3 and 2005-015 are highly significant. The pod length in TPI-2429, TPI-178, 2005-014, 118-2, TPI-189, 2005-015 and 2006-003B are highly significant, while TPI-2429, TPI-178,118-2, TPI-198, 198-3, TPI-189, 2006-003A, 2005-015and 2006-003A accessions are highly significant for pod width. The accessions; 2005-011, TPI-178118-2 and 2006-003B are highly significant for weight of fresh pod, while TPI-2429, 198-3, TPI-189, 2006-003A

accessions are highly significant for seed length. The 2005-011 and 2005-014 accessions are highly significant, while 2005-011, TPI-178, 2006-005A, PS-16, 2006-007 and 2006-015 are significant at $p<0.05$. The result of the mean square variance of lima beans growth characters is shown in Table 4. The plant height and number of leaves had no significant effect, but had significant effect on leaf length across the accession number (r=0.05). Leaf width and petiole length was highly significant in accessions but not significant in replicates. Plant height, leaf width, petiole length and number of leaves had no significant effect across replicate, but was significant on leaf length.

The result of mean square variance of genotypic effect on the yield characters in table 5 shows that the number of pods perrep,number ofseedsperpod,number ofloculesperpod,numberofseedsperrep,podlength,podwidth,weightof fresh pod, seed length, seed width, seed thickness and 100 seed weight were significant. The result of growth character associations in Lima beans accessions in Table 6 shows thatstrongpositivecorrelationexistsbetweentheleaflengthandleafwidth (r=0.82)andalsopositively associated with petiole length (r =0.71). More so, leaf width had strong positiverelationshipwith petiole lengthat r=0.74.

The associations of yield traits in Lima beans accessions are shown in a correlation matrix (Table7).Seedlengthhadstrongsignificantpositivecorrelationwithseedwidth r=0.87 and 100 seed weight (r=0.78). Seed width is positive and stronglycorrelatedwith100seedweight(r=0.76).Numberofpodsperrephadpositive and strongassociation with number of seeds per pod (r=0.82), number of seeds per rep (r=0.95), number of locules perpod(r=0.82), fresh pod weight (r=0.89), pod length (r=0.81), and pod width (r=0.73) while, number ofseeds per pod had strong positive correlation with number of seeds per rep (r=0.74), number of loculesperpod(r=1.00),freshpodweight(r=0.71),podlength(r=0.07),andpodweight(r=0.94).Numberofseedsperrephadstrongpositivecorrelationwithnumberofloculesperpod(r=0.74),freshpodweight(r=0.82),podlength(r=0.72)andpodwidth(r=0.64).Numberofloculesperpodhadstrongpositivecorrelationwithfreshpodweight(r=0.71),podlength(r=0.97)andpodwidth(r=0.94). More so, freshpodweight ispositive and stronglyrelatedwithpodlength(r=0.73)andpodwidth(r=0.64).Also, podlength had positive and strongcorrelation with pod width (r=0.93).

The data of qualitative character arerepresented in Tables 8. The qualitative traits scored from 15 accessions of lima beans were plant type, leaf type, seed shape, seed colour, flower wings,pod colour, pod tip, pattern colour, and pod curvature. Accessions 2005-014, 2005-011, TPI-178and2006-005A werebushplanttype,alsocalledbushlima,while2006-003A,2006-015,TPI-2429,TPI-189,TPI-198,118-2,198-3,PS-16,2005-015,2006-003Band2006-007werevined.The leaf shape was Ovate-lanceolatein 2006-003A, 2006-015, 198-3, PS-16, 2005-015 and 2006-003B, lanceolate in TPI-2429 and TPI-189,round in TPI-198,118-2 and2006-007. Ovatein 2005-014, 2005-011,TPI-178 and2006-005A.

The flower wings for all accessions appeared white yellow wings except for TPI-178 that is white. Similarly, pod colour (young), pod colour, pod tip in all accessions were green, short and brown, while the pod curvature was slightly curved in 13 accessions, but straight in 2006-015 and 2006-007 accessions. The seed shape was wide flat kidney for accessions TPI -198 and 118-2, but round in 2006-007, 2005-

014, 2005-011, 2006-005A, PS-16 and 2005-015. The 193-3, medium flat kidney in TPI-178, Oval cuboid in 2006-003B, kidney in 2006-003A and very wide flat kidney in TPI-2429. The seed colour of accessions 2006-003A, 2006-015, 2005-014, 2006-005A and 2005-015 were buff, while 2005-11, TPI-178, PS-16 and 2006-003B accessions were maroon and accession TPI-2429 was dark brown, TPI-189 and 2006-007 were white, 198-3 was brown and TPI-198 and 118-2 were light brown. The pattern colour trait was dark brown in 2006-015, TPI-198, 118-2 and 198-3 accessions, black in accessions 2006-007, 2005-011 and 205-015, while no pattern was observed in 2006-003A, TPI-2429, TPI-189, 2005-014, TPI-178, 2006-005A, PS-16 and 2006-003B accessions.

Three accessions (2006-003A, 2006-003B, and 2006-005A) cameoutnot decided. Accession PS-16 had thehighestlevel of cyanide with 0.03mg/kg followed by TPI-2429 (0.02mg/kg) and then 2005-014 (0.01mg/kg)than other accessions as shown in Table 9. Theresultinfigure1showingPC1ofgrowthcharacters revealedthatleafwidth,leaflengthand petiole length are closely related to each other but not closely related to plant height andnumber of leaves which are closely associated to leaf width, leaf lengthand petiole length are not related to one another.

The result of PC2 showing yield characters in figure 2 revealed that seed length, seed width, and100 seed weight are closely related but not related to pod width, pod length,number of locules per pod, number of seeds per pod, seed thickness, fresh pod weight, number ofpods per rep and number of seeds per rep. The pod width, pod length, number of locules per pod andnumber of seeds per pod are closely related to one another, but not related to seed length,seedwidth,100seedweight,seedthickness,freshpodweight,numberofpodsperrepandnumberof seeds per rep. Seed thickness, fresh pod weight, number of pods per rep and number of seedsper rep are closely related to one another but not closely related to pod width, pod length, numberoflocules perpod, numberofseedsper pod,seedlength, seedwidth and100seed weight.

Table 2:GrowthPerformanceof LimaBeansAccessions.

ACCESSION NO	PH(cm)	LL(cm)	LW(cm)	PL(cm)	NOL
TPI-2429	6.80^{a}	6.38^{h}	4.95^{e}	5.17^{f}	8.90^{a}
2005-011	8.17^{a}	7.02^{fgh}	7.84^{bcd}	7.25^{bcdef}	12.43^{a}
TPI-178	8.26^{a}	6.76^{gh}	9.23^{ab}	6.89^{bcdef}	10.57^{a}
2005-014	8.64^{a}	7.60^{efgh}	7.59^{cd}	5.17^{a}	10.76^{a}
118-2	10.01^{a}	8.73^{bcde}	7.59^{cd}	6.61^{cdef}	7.63^{a}
TPI-198	11.86^{a}	8.73^{bcde}	8.03^{bcd}	7.42^{bcdef}	7.48^{a}
2006-005A	12.20^{a}	8.10^{defg}	6.96^{d}	7.67^{abcde}	9.76^{a}
2006-007	14.80^{a}	8.57^{cde}	8.33^{abcd}	8.50^{abcd}	10.76^{a}
PS-16	12.42^{a}	9.48^{abcd}	9.07^{abc}	9.06^{abc}	8.57^{a}
198-3	15.56^{a}	9.83^{abc}	8.51^{abc}	8.91^{abc}	10.95^{a}
TPI-189	15.80^{a}	9.548^{a}	9.548^{a}	6.44^{def}	10.38^{a}

2006-015	**16.02^{a}**	**7.87^{bcd}**	**7.87^{bcd}**	**5.85^{ef}**	**7.71^{a}**
2006-003A	**16.32^{a}**	**7.02^{d}**	**7.02^{d}**	**8.91^{abc}**	**9.95^{a}**
2005-015	**16.94^{a}**	**8.98^{abc}**	**8.98^{abc}**	**9.89^{a}**	**10.05^{a}**
2006-003B	**18.20^{a}**	**8.83^{abc}**	**8.83^{abc}**	**9.31^{ab}**	**7.71^{a}**

Meanwithdifferentlettersinthesamecolumnaresignificantlydifferentfromeachotheratp<0.05accordingtoDuncanMultipleRangeTest (DMRT).

PH-Plantheight,LL-leaflength,LW-leafwidth,PL-petiolelength,NOL-numberofleaves.

Table3:YieldPerformanceofLimaBeansAccessions

ACCESSIONNO	NOPPR	NOSPP	NOLPP	NOSPR	PL(cm)	PW(cm)	WOFP(g)	SL(cm)	SW(cm)	ST(mm)
TPl-2429	36.33^{ab}	3.00^{ab}	3.00^{ab}	109.00^{abc}	7.66^{ab}	1.90^{ab}	129.33^{a}	11.26^{h}	8.25^{gh}	4.08^{h}
2005-011	26.33^{bcd}	2.67^{b}	2.67^{b}	132.00^{ab}	5.50^{b}	1.40^{b}	52.33^{bc}	15.23^{c}	10.77^{b}	3.50^{i}
TPl-178	19.67^{cde}	3.00^{ab}	3.00^{ab}	59.00^{bcd}	6.66^{ab}	1.70^{ab}	52.67^{bc}	16.67^{b}	9.49^{de}	3.64^{i}
2005-014	47.00^{a}	4.00^{a}	4.00^{a}	175.33^{a}	8.10^{ab}	2.23^{a}	109.00^{a}	14.11^{e}	10.91^{b}	4.23^{gh}
118-2	18.00^{de}	3.00^{ab}	3.00^{ab}	54.00^{cd}	6.66^{ab}	2.07^{ab}	50.33^{bc}	13.87^{e}	9.11^{f}	6.15^{ab}
TPl-198	13.33^{def}	2.67^{b}	2.67^{b}	38.33^{cd}	5.80^{a}	1.83^{ab}	33.00^{c}	14.67^{d}	9.69^{c}	4.39^{g}
2006-005A	0.00^{f}	0.00^{c}	0.00^{c}	0.00^{d}	0.00^{c}	0.00^{c}	0.00^{d}	0.00^{j}	0.00^{i}	0.00^{j}
PS-16	0.00^{f}	0.00^{c}	0.00^{c}	0.00^{d}	0.00^{c}	0.00^{c}	0.00^{d}	0.00^{j}	0.00^{i}	0.00^{j}
2006-007	0.00^{f}	0.00^{c}	0.00^{c}	0.00^{d}	0.00^{c}	0.00^{c}	0.00^{d}	0.00^{j}	0.00^{i}	0.00^{j}

198-3	**10.67^{ef}**	**3.00^{ab}**	**3.00^{ab}**	**32.00^{cd}**	**5.66^{b}**	**1.83^{ab}**	**40.33^{c}**	**11.38^{h}**	**8.11^{h}**	**5.97^{b}**
TPl-189	**11.00^{ef}**	**3.00^{ab}**	**3.00^{ab}**	**33.00^{cd}**	**6.46^{ab}**	**2.17^{ab}**	**8.33^{cd}**	**12.15^{h}**	**8.45^{g}**	**4.70^{f}**
2006-015	**0.00^{f}**	**0.00^{c}**	**0.00^{c}**	**0.00^{d}**	**0.00^{c}**	**0.00^{c}**	**0.00^{d}**	**0.00^{e}**	**0.00^{i}**	**0.00^{j}**
2006-003A	**32.67^{bc}**	**4.00^{a}**	**4.00^{a}**	**130.67^{ab}**	**8.46^{a}**	**1.90^{ab}**	**96.00^{ab}**	**11.54^{h}**	**8.23^{gh}**	**5.67^{c}**
2005-015	**14.33^{def}**	**3.00^{ab}**	**3.00^{ab}**	**43.00^{cd}**	**7.33^{ab}**	**2.03^{ab}**	**37.00^{c}**	**13.79^{e}**	**9.22^{ef}**	**5.43^{d}**
2006-003B	**23.00^{bcde}**	**3.00^{ab}**	**3.00^{ab}**	**69.00^{bcd}**	**6.33^{ab}**	**1.97^{ab}**	**48.33^{bc}**	**10.05^{i}**	**8.06^{h}**	**5.16^{e}**

Meanswithdifferentlettersinthesamecolumnaresignificantatp<0.05accordingtoDuncanMultipleRangeTest (DMRT)

NOPPR-NumberofPodsperrep,NOSPP-NumberofSeedsperpod,NOLPP-Numberofloculesperpod,NOSPR-NumberofSeedsperrep, PL-Pod length,PW-PodWidth,WOFP-Weight offresh Pod, SL-SeedLength, SW-SeedWidth,ST-Seed thickness

Table4:MeanSquareVarianceof GrowthCharactersin LimaBeans accessions

Source of Variation	Df	PH	LL	LW	PL	No of Leaves
Corrected Model	44	144.01	28.06	19.04	23.36	35.94
Intercept	1	48485.79	21062.34	18505.67	17027.62	26829.36
Accession Number	14	285.16^{ns}	43.52**	33.32**	45.01**	48.41^{ns}
Replicate	2	39.55^{ns}	21.46**	16.30^{ns}	12.25^{ns}	8.71^{ns}
Error	264	445.46	2.63	2.97	10.86	171.92
Corrected Total	308					

**ishighlysignificant atP<0.01, ns=notsignificant

Df-degreeoffreedom,PH-Plantheight, LL- leaf length,LW-leafwidth,PL-petiolelength,NOL- numberofleaves.

Table5:**MeanSquareVarianceof YieldCharactersin LimaBeans accessions**

Sourceofvariation	Df	SL	SW	ST	NOPPR	NOSPR	NOSPP	NOLPP	WOFP	PL	PW	100 SEED WEIGHT
Corrected Model	14	22.21	6.41	2.76	621.99	6.56	9134.87	6.56	4883.29	310.7	2.41	405.72
intercept	1	223917.16	145034.37	78656.01	203.14	624.06	92.45	624.06	107.52	598.04	568.80	0.00
Accession Number	44	22.21**	6.41**	2.76**	621.99**	6.56**	9134.87**	6.56**	4883.29**	310.7**	2.41**	405.72**
Error	30	0.04	0.03	0.02	62.68	0.37	1657.53	0.37	837.48	1.86	0.15	0.00
Corrected total	44											

**is highlysignificant at P<0.01

Df- degree of freedom, NOPPR- Number of Pods per rep , NOSPP- Number of Seeds per pod, NOLPP- Number of locules per pod, NOSPR-NumberofSeedsperrep,PL-Podlength,PW-PodWidth,WOFP-Weight offreshPod,SL-SeedLength,SW-SeedWidth, ST-Seedthickness

Table6:CorrelationonGrowthCharactersofLimaBean

	LL	LW	PL	NOL
PH	-0.16	-0.26	-0.27	0.33
LL		0.82**	0.71**	0.09
LW			0.74**	0.09
PL				-0.05
NOL				

**is highlysignificantatP>0.5

PH-Plantheight,LL-leaflength,LW-leafwidth,PL-petiolelength,NOL-numberofleaves.

Table7Correlationon yield charactersof Limabean

	SW	ST	NOPPR	NOSPP	NOSPR	NOLPP	WOFP	PL	PW	100 SEED WEIGHT
SL	0.87**	-0.8	-0.27	-0.36	-0.19	-0.36	-0.29	-0.36	-0.37	0.78**
SW		-0.24	-0.12	-0.33	-0.23	-0.33	-0.19	-0.34	-0.36	0.76**
ST			-0.29	-0.13	-0.29	-0.13	-0.25	-0.14	-0.09	-0.01
NOP				0.82**	0.95**	0.82**	0.89**	0.81**	0.73**	-0.16
NOSP					0.74**	1.00**	0.71**	0.97**	0.94**	-0.23
NOS						0.74**	0.82**	0.72**	0.64**	-0.25
NOLP							0.71**	0.97**	0.94**	-0.23
WOFP								0.73**	0.64**	-0.21
PL									0.93**	-0.26
PW										0.29

**is highlysignificantatP>0.5

NOPPR-NumberofPods per rep,NOSPP-NumberofSeedsperpod,NOLPP-Numberofloculesperpod,NOSPR-NumberofSeeds per rep,PL-Podlength,PW-PodWidth,WOFP-Weight of fresh Pod, SL-SeedLength, SW-SeedWidth, ST-Seed thickness.

Table8a:QuantitativeCharacters of Lima Beans Accessions

Accession No	PlantType	Leaf Shape	FlowerWings	Pod colour(young)	PodTip	Podcurvature	Seed Shape	Seed Colour	PodColour	PatternColour
2006-003A	Vine	Ovatelanceolate	white-yellow	Green	short	slightly curved	kidney	buff	brown	no pattern
2006-015	Vine	Ovatelanceolate	white-yellow	Green	short	Straight	wide flat kidney	buff	brown	darkbrown
TPI-2429	Vine	lanceolate	white-yellow	Green	short	slightly curved	very wideflatkidney	darkbrown	brown	no pattern
TPI-189	Vine	lanceolate	white-yellow	Green	short	Slightly curved	flatkidney	white	brown	no pattern
TPI-198	Vine	Round	white-yellow	Green	short	Slightly curved	wide flat kidney	light brown	brown	dark brown
118-2	Vine	Round	white-yellow	Green	short	slightly curved	wide flat kidney	lightbrown	brown	darkbrown
198-3	Vine	Ovatelanceolate	white-yellow	Green	short	slightly curved	wide flat kidney	brown	brown	darkbrown

2006-007	Vine	Round	white-yellow	Green	short	Straight	round	white	brown	black

Table8b:QuantitativeCharacters of Lima Beans Accessions

Accession No	PlantType	Leaf Shape	FlowerWings	Pod colour(young)	PodTip	Podcurvature	Seed Shape	Seed Colour	PodColour	PatternColour
2005-014	Bush	Ovate	white-yellow	Green	short	Slightly curved	round	buff	brown	no pattern
2005-011	Bush	Ovate	white-yellow	Green	short	slightly curved	round	maroon	brown	black
TPl-178	Bush	Ovate	white	Green	Short	Slightly curved	mediumflatkidney	maroon	brown	nopatteren
2006-005A	Bush	Ovate	white-yellow	Green	Short	slightly curved	round	buff	brown	nopatteren
PS-16	Vine	Ovate lanceolate	white-yellow	Green	Short	slightly curved	round	maroon	brown	no pattern
2005-015	Vine	Ovatelanceolate	white-yellow	Green	Short	slightly curved	round	buff	brown	black
2006-003B	Vine	Ovatelaceolate	white-yellow	Green	short	slightly curved	ovalcuboid	maroon	brown	no pattern

Table9: Cyanidetest

SAMPLE	REPLICATES	SAMPLECYANIDE(mg/kg)
2005-014	1	0.01
	2	0.01
	3	0.01
2006-003A	1	ND
	2	ND
	3	ND
2006-003B	1	ND
	2	ND
	3	ND
2006-005A	1	ND
	2	ND
	3	ND
PS-16	1	0.03
	2	0.02
	3	0.03

TPl-2429	1	0.02
	2	0.02
	3	0.01

ND=NotDecided

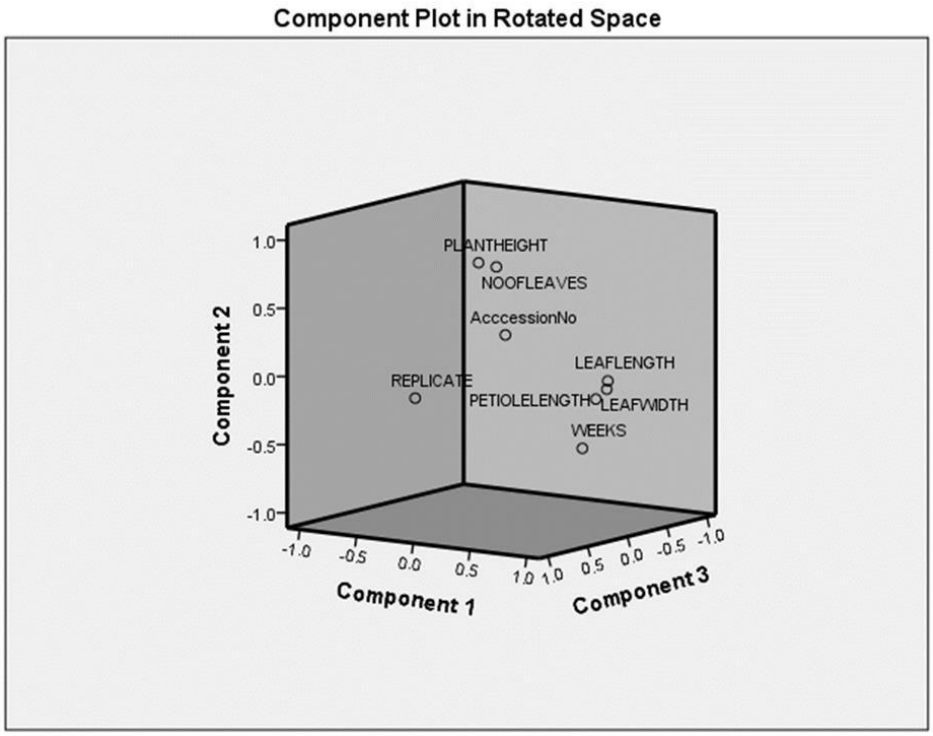

Figure1:Principal Component of showing the Growth Characters of Lima Beans Accessions.

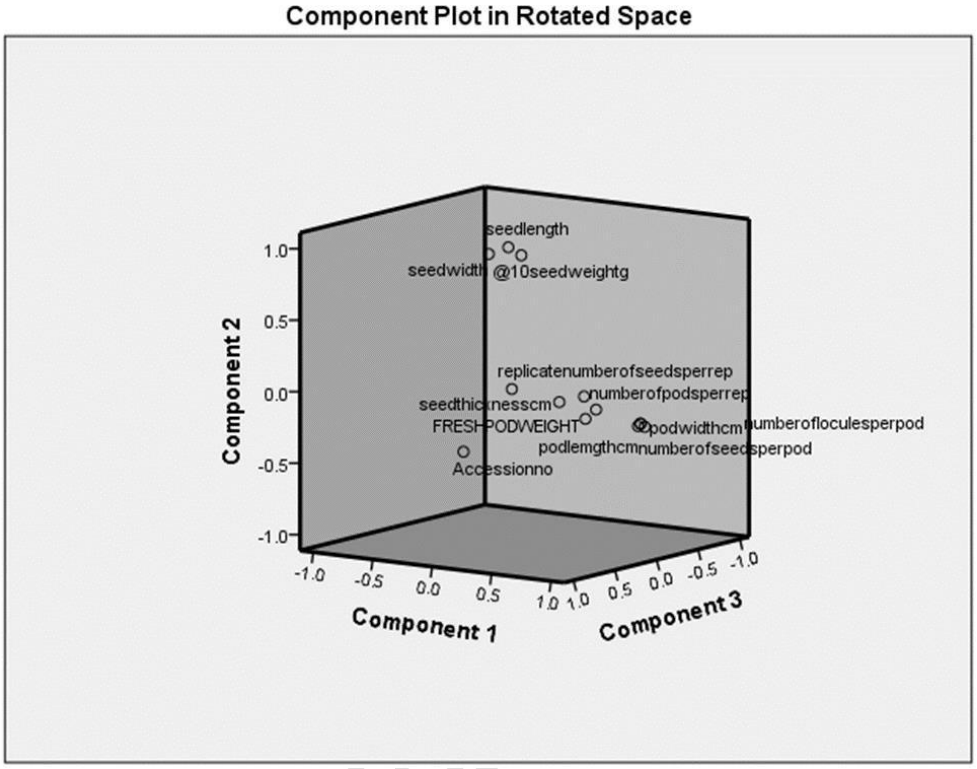

Figure2:Principal Component of Yield Characters in Lima BeansAccessions

4.0 DISCUSSION

Comment [dh3]: Need more paragraph in-depth discussion

This study revealed variation in morphological characteristics of fifteen accessions of Lima beans. 2005-014 accessions performed best for most of the character scored. Accessions TPl-2429 and 2006-003A performed best in yield related characters. The variation shown by the characters could be as a result of high genetic diversity, differences of growing type and difference in the type of adaptation as similarly reported by Kulakow (1987), Mujica and Jacobsen (2003) and Montero-Rojas *et al*. (2013). It was observed that 2005-011, 2005-014 and TPl-178 accessions germinated earlier, flowered with white-yellow, podded earlier and had good yield than other accessions are in agreement with the findings made by Yaguiu *et al.* (2003) and Gepts (2012) who reported yield and pattern of color on the skin of the seeds as a factor of biochemical pigmentation process and a characteristics of wild type character of the cultivated species.

Findings from correlation of growth characters revealed that the leaf length and leaf width of Lima bean significantly influenced petiole length positively, but did not affect the height of the plant. Again, the yield characters such as number of pods per rep, number of seeds per pod, number of locules per pod, number of seeds per rep, pod length, pod width, weight of fresh pod, seed length, seed width, seed thickness and 100 seed weight significantly associated with one another. This implies that these characters can be improved based on this selection criterion to enhance growth and performance of various legumes in plant population as similarly reported by Porbeni *et al.* (2018).

Comment [dh4]: Elaborate what is the negative effect of cyanide

Levels of cyanide is significantly far lower than oral toxicity standard of 50 to 90 mg HCN equivalent/Kg body weight (WHO, 2004), less than the lethal dose of cyanide intoxication of human which has been reported as 200 to 300 mg/kg by Akiyama *et al.* (2006) in mushroom and also, less than permissive dosage reported by Orjiekwe *et al.* (2013)) as well as lower than100- 120 ppm/100-120mg/kg stated by Baudoin (2006) who observed that domesticated Lima bean species contained plant rich nutrients, and had shown that cooking and differentothermodificationswereusedtoreducecyanidecontentpresentinthebeans.

CONCLUSIONANDRECOMMENDATION

Accession 2005-014 had the highest growth and yield performance. The Leaflength,LeafwidthandPetiolelengtharefoliar characters as well as seed length, seed width,numberofpodsperrep,numberofseedsperpod,numberof seedsperrep,numberoflocules perpod,freshpodweight,andpodlength whichareyieldcharacters should be considered inbreedingof limabeans. The three accessions (2006-003A, 2006-003B, 2006-005A) which

hadnocyanidecontentscannot be harmful to the body system. Therefore, TPI-2429, 2006-003A and 2005-011 accessions which showed higher growth and yield characters with no cyanide content could be further improved in breeding of lima beans.

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