Effects of phosphorus rates, sowing date and variety on growth and yield of hyacinth bean (*Lablab purpureus* (L.) Sweet) in Ringim, Jigawa State, Nigeria

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Abstract
Field experiment was conducted during the 2019, 2020 and 2021 cropping seasons at the Jigawa State Horticultural Farm, Ringim in the semi-arid zone of Nigeria. The experiment was conducted to determine the effect of phosphorus, sowing dates and variety on the growth and yield characters of lablab. The treatments consisted of four levels of phosphorous (0, 20, 40 and 60 kg/ha), two local varieties of lablab (Dan Inusa and Dan Farankachi) and three sowing dates (1st, 15th and 29th of July). The experiment was laid out in a Randomized Complete Block Design (RCBD) replicated three times. Growth and yield characters were measured and correlation analysis was done. Results indicated that 60 Kg P/ha produced highest seed yield. Sowing on 29th of July had highest yield and Variety Dan Inusa out yielded the other variety. The results also showed that most of the growth and yield components had significant positive correlation with yield. However, crop growth rate was observed to have significant negative correlation with the crop yield. It could be recommended that most of the growth and yield parameters were good yield contributing characters.

Keywords: Growth, Yield characters. Correlation

Introduction
Hyacinth bean (*Lablab purpureus* (L.)*Sweet*) is a prehistoric crop widely grown in the tropics and subtropics mostly in mixed crop-livestock systems (Kimani *et al.*, 2012). It is broadly distributed and domesticated in Africa, the Indian subcontinent and Southeast Asia as a grain legume and vegetable (Bryegowda *et al.*, 2015). In Africa, the lablab bean is mostly grown and adapted as a pulse crop (Ewansiha*et al.*, 2007: Lablab, 2013). As an indigenous leguminous cover crop in Africa that once fed much of the continent, largely through household garden production by women (Bryegowda *et al.*, 2015), however, values for the crop was lost to most of Africa during the colonial era when farmers were encouraged, or forced, to grow maize and common beans intended for export markets. Lablab is one of the most ancient crops among cultivated plants (Bryegowda *et al.*, 2015).

Traditionally, legumes have played an important role in farming systems of the Africa region (Maass *et al.*, 2010). Legumes are cultivated

throughout semi arid areas and are frequently subject to water stress (Maass *et al.*, 2010). Hyacinth bean(*Lablab purpureus* (L.)*Sweet*) is one of those crops that have the ability to grow deep tap roots enabling the plant to reach deep residual soil moisture (Maass *et al.*, 2010; Whitbread *et al.*, 2011; Guretzki and Papenbrock, 2013). Lablab is considered to cope better with arid and semi arid conditions compared to some of the more widely grown legumes such as common beans (*Phaseolus vulgaris* L.) or cowpeas (*Vigna unguiculata* L. Walp.) (Maass *et al.*, 2010). Moreover, lablab is a traditional food and fodder crop in Africa, (Maass*et al.*, 2010; Whitbread *et al.*, 2011), and offers great potential for smallholder farming systems in the semi-arid regions (Osman, 2007). Despite its earlier wide distribution in Africa, today lablab is regarded as a minor and neglected crop; its cultivation area is in steady decline (Maass *et al.*, 2010). The experiment was conducted to determine the relationship between the growth and yield characters of lablab and determine the most important yield contributing characters to the yield of lablab.

Materials and Methods

Field experiment was conducted during the 2019, 2020 and 2021 cropping seasons at the Jigawa State Horticultural Farm, Ringim (Latitude 12° 11'N and 12° 14'N and Longitude 8° 10' and 8° 38' E) in the semi-arid zone of Nigeria.. The soil of the experimental sites was sandy loam. The rainfall distribution pattern is unimodal. It starts in June and ends in October with a mean annual rainfall of about 400 - 800 mm. Treatments consisted of factorial combinations of four levels of phosphorous (0, 20, 40 and 60), two local varieties of lablab (*Dan Inusa* and *Dan Farankachi*) and three dates of sowing (1st, 15thand 29th of July) laid out in a Randomized Complete Block Design (RCBD) replicated three times.

The seeds of lablab varieties were obtained from the farmers of the research area and sown according to the treatment in all cropping seasons. Two seeds were sown per mound at a depth of 3 - 4 cm and 100 cm apart at a plant-to-plant spacing of 50 cm within a row. Urea at the rate 20 kgha^{-1} was applied as a starter dose to all the plots while P_2O_5 was applied as per treatment (0, 20, 40, and 60 kg P_2O_5 ha^{-1}).Glyphosate (1.8 kgha^{-1}) was applied before land preparation, while hoe weeding was carried out at 6WAS, supplementary hand pulling was carried out for undesirable weed species that grew above the canopy.

Chemical analysis of the soil

Particle size distribution was determined by the hydrometer method (Bouyoucos, 1962) using sodium hexameta-phosphate as dispersing agent. Soil pH was determined in distilled water at soil to water ratio 1:1 using glass electrode on an EIL 7030 pH meter. Exchangeable bases (K, Na, Ca, and Mg) were determined by extraction with neutral 1 M NH_4OAC at soil: solution ratio 1:10. Potassium,

calcium and sodium in the extract were read by flame photometer while magnesium was determined by atomic adsorption spectrophotometer.Soil exchangeable acidity was determined by titration of normal KCl extracted acidity against 0.05N sodium hydroxide to a pink end point using phenolphthalein as indicator (Kitson and Mellon, 1994). Cation exchange capacity was obtained by summation of exchangeable cation (K, Na, Ca, and Mg) and exchange acidity. Available P was determined using 0/03N NH_4F in 0.025N HCl as extractant. Organic carbon was determined by wet oxidation with sulphuric acid.

Growth and yield data were collected subjected to analysis of variance to test the significance of treatment effects, and the means were separated using Duncan's Multiple Range Test (DMRT) (Duncan, 1955). Correlation analysis was also done to determine the relationship between variables.

Results and discussion

The Physico-chemical Properties of the soil prior to commencement of the experiment is presented in Table 1. Soil textural class ranged between sandy to loam, slightly acidic, with low Organic Carbon, Total Nitrogen, available Phosphorus and low Exchangeable bases irrespective of the seasons and depth were relatively low (Table 1). It can be inferred from the result that the soil is low in fertility and could respond well to soil amendment which will in turn boost the production of Hyacinth beam in the region. The performance of lablab was significantly increased by the application of 60 kg/ha of phosphorus. Planting on the 29th of July significantly produced higher seed yield than the other sowing dates. Variety Dan Inusa out yielded the other variety in both years of the experiment (Table 2).

The Correlations between Growth and Yield Characters of Hyacinth bean in 2019 wet season are presented in Table 3. Plant height, number of branches, leaf area index, number of nodes per plant, number of pods per plant, pod length, pod width, phosphorus uptake, number of seed per pod, hundred seed weight and pod yield had a highly significant positive correlation of 0.741**, 0.652**, 0.708, 0.708**, 0.733**, 0.810**, 0.579**, 0.650**, 0.875**, 0325**, 0.836** and 0.725**, respectively to seed yield. Crop growth rate had a significant negative correlation of -0.599** to the yield of crops.

Table 4 shows the relationship between growth and yield characters of Hyacinth bean in 2020 wet season. Plant height, number of branches, leaf area index, number of nodes per plant, number of pods per plant, pod length, pod width, phosphorus uptake, number of seed per pod, hundred seed weight and pod yield had a highly significant positive correlation of 0.591** , 0.685**, 0.733**, 0.810**,0.717**, 0.500**, 0.544**, 0.930**, 0.605** 0.787**, and 0.813**, respectively to seed yield. Crop growth rate had a significant negative

correlation of -0.651** to seed yield of crop.

Table 5 reveals the relationship between growth and yield characters and seed yield of lablab in 2021 wet season. Plant height, leaf area index, number of nodes per plant, number of pods per plant, pod width, phosphorus uptake and number of seed per pod had a highly significant positive correlation of 0.460**, 0.515**, 0.567**, 0.542**, 0.539**, and 0.457**, respectively to seed yield. Hundred seed weight and pod yield had significant positive correlation of 0.414* and 0.418* respectively. Similarly, crop growth rate had a significant negative correlation of -0.390** to seed yield.

Table 6 shows the combined correlation indicating relationship between growth and yield characters and seed yield of lablab in 2019, 2020 and 2021 wet seasons Plant height, number of branches, leaf area index, number of nodes per plant, number of pods per plant, pod length, pod width, phosphorus uptake, number of seed per pod, hundred seed weight and pod yield had a highly significant positive correlation of 0.601**, 0.532**, 0.554**, 0.659**, 0.694**, 0.409**, 0.654**, 0.763**, 0.500**, 0.654** and 0.624**, respectively to seed yield. Crop growth rate had a significant negative correlation of -0.554** to seed yield.

A multiple regression analysis was also conducted to examine the extent of the relationship between yield and other yield characters as summarized in Table 7. The results obtained in 2019, 2020 and 2021 seasons on plant height, number of branches, leaf area index, number of pods per plant, number of nodules per plant and pod yield per plant, with coefficient of determination that shows number of pods per plant added significantly ($P \leq 0.01$) to seed yield of the crop.

The highly significant correlation of plant height, number of branches, leaf area number of nodules per plant, number of pods per plant, pod length, pod width, phosphorus uptake, number of seed per pod, 100 seed weight and pod yield per hectare to seed yield might be contributed to the longer pod with higher seed yield. The result is in line with the earlier report of Yahaya *et al.* (2005) that pod length of cowpea was positively and significantly correlated with green pod yield. The highly significant positive correlation of plant height to seed yield may be attributed to the higher the plant height with number of leaves formed which may in turn increased Leaf Area Index (LAI); since photosynthetic area increased dry matter accumulation hence increased assimilates which then partitioned to the sink (seed). The highly significant positive relationship of number of branches to seed yield might be due to the fact that increase in branches may mean higher number of leaves which resulted to higher accumulation of photo-assimilates and hence higher vegetative production at the expense of yield. Pod width was significantly and positively correlated with number of seed per pod this indicating dependence of these characters on each other, and similar findings were

reported by Adak and Kibritc (2016) for pod length. CGR was non-significantly and positively correlated with seed yield. Similar results were reported by number of seeds per pod; Desai *et al.* (1996); Adak and Kibritc (2016). It could therefore be concluded that most of the growth and yield characters measured performed better at 60kg/ha application rate of Phosphorous and on crops planted towards ending of July. From the forgoing, it can thus be suggested for recommendation that Hyacinth bean being a grain legume be cultivated towards ending of July when the rains have stabilized and with fertilizer application rate of 60 kg/ha single super phosphate for enhanced pod and seed formation to meet the protein needs of the populace in Ringim and environs.

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Table 1: Soil Physical and Chemical Properties of the soils in the experimental sites

	Year					
	2019		2020		2021	
	0-15cm	15-0cm	0-15cm	15-0cm	0-15cm	15-0cm
Particle Size Distribution						
Sand (%)	46	56.8	61.8	58.9	61.4	59.7
Silt (%)	25.9	28.4	25.5	26.8	26.0	25.4
Clay (%)	12.2	14.8	12.7	14.3	13.6	14.9
Textural class	Sandy-Loam		Sandy-Loam		Sandy-Loam	
Chemical Composition						
pH in H_2O (1:2.5)	5.90	5.50	6.10	6.0	5.00	5.60
pH in 0.01M $CaCl_2$(1:2.5)	5.10	4.80	4.50	4.70	4.90	4.80
Organic Carbon (gkg^{-1})	7.5	3.9	3.5	2.4	4.3	3.7
Total Nitrogen (gkg^{-1})	0.6	0.4	0.9	0.6	0.7	0.5
Available phosphorus ($mg\ kg^{-1}$)	5.37	4.38	5.41	5.12	5.72	4.63
Exchange bases ($Cmol\ kg^{-1}$)						
Ca	3.61	2.26	2.10	1.76	2.70	2.00
Mg	1.02	0.87	0.84	0.71	0.74	0.44
Na	0.11	0.10	0.12	0.10	0.16	0.14
CEC	5.10	4.70	5.30	4.90	5.20	4.50

Table 2: Effect of sowing date and phosphorus level on Seed Yield per Hectare of Lablab Varieties in 2019, 2020, 2021 wet seasons and Combined at Ringim

Treatments	2019	2020	2021	Combined
Phosphorus Levels (kg/ha)				
0	2.4772d	2.4072d	2.611d	2.4983c
20	2.5983c	2.6317c	2.939c	2.7231b
40	3.1222b	3.3233b	3.179a	3.2083a
60	3.1939a	3.3894a	3.017b	3.2002a
Level of Probability	<0.001	<0.001	<0.001	<0.001
SE±	0.014	0.015	0.021	0.010
Sowing Dates				
1st July	2.8162b	2.9179b	2.949	2.8943b
15th July	2.8717a	2.9008b	2.932	2.9015b
29th July	2.8555a	2.9950a	2.929	2.9267a
Level of Probability	0.006	<0.001	0.706	0.028
SE±	0.011	0.013	0.017	0.084
Varieties				
Dan Farankachi	2.760b	2.8603b	2.789b	2.8034b
Dan Inusa	2.9353a	3.0156a	3.084a	3.0116a
Level of Probability	<0.001	<0.001	<0.001	<0.001
SE±	0.098	0.011	0.015	0.068
Interactions				
P*S	NS	**	**	**
P*V	NS	NS	**	**
S*V	NS	NS	NS	NS
P*S*V	NS	NS	**	**

Means in the same column followed by the same letter (s) are not significantly different at 5% level of probability using Duncan's Multiple Range Test (DMRT)

Table 3: matrix of correlation showing the relationship between growth, and yield characters of lablab in 2019 wet season

	ST	PT	SW	NS	PU	PW	PL	NP	ND	CGR	LA	NB	PH
ST	1												
PT	0.725**	1											
SW	0.836**	0.662**	1										
NS	0.325*	0.273ns	0.353*	1									
PU	0.875**	0.651**	0.764**	0.312ns	1								
PW	0.650**	0.657**	0.562**	0.243*	0.498**	1							
PL	0.579**	0.622**	0.452**	0.174ns	0.369*	0.914**	1						
NP	0.810**	0.572**	0.700**	0.312ns	0.860*	0.454**	0.374**	1					
ND	0.733**	0.610**	0.695**	0.350*	0.800**	0.468**	0.344*	0.618**	1				
CGR	-0.599**	-0.493**	-0.497**	-0.271*	-0.630**	-0.338*	-0.247ns	0.590**	-0.487**	1			
LA	0.708**	0.504**	0.596**	0.127ns	0.671**	0.378*	0.363*	0.673*	0.549**	-0.442*	1		
NB	0.652**	0.350**	0.567**	0.174ns	0.688**	0.140ns	0.062ns	0.665**	0.536**	-0.429*	0.599**	1	
PH	0.741**	0.465**	0.675**	0.125ns	0.719**	0.307ns	0.214ns	0.569**	0.596**	-0.513**	0.609**	0.607**	1

ST= Seed Yield per Hectare. PT=Pod Yield per Hectare. SW= Hundred Seed Weight. NS= Number of Seed per Pod. PU=Phosphorus Uptake. PW= Pod Width. PL= Pod Length. NP=Number of Pod per Plant. ND= Number of Nodes per Plant. CGR=Crop Growth Rate. LA=Leaf Area Index. NB=Number of Branches. PH= Plant Height. * = significant df at 5% level. ** = highly significant df at 1% level. ns = not significant.

Table 4: matrix of correlation showing the relationship between growth, and yield characters of lablab in 2020 wet season

	ST	PT	SW	NS	PU	PW	PL	NP	ND	CGR	LA	NB	PH
ST	1												
PT	0.813**	1											
SW	0.787**	0.607**	1										
NS	0.605**	0.482**	0.565**	1									
PU	0.930**	0.739**	0.789*	0.618**	1								
PW	0.544**	0.735**	0.410*	0.269*	0.482**	1							
PL	0.500**	0.747**	0.353*	0.242*	0.425**	0.978**	1						
NP	0.717**	0.527**	0.540**	0.469**	0.727**	0.276*	0.234	1					
ND	0.810**	0.645**	0.784**	0.574**	0.816**	0.385**	0.361	0.496**	1				
CGR	-0.651**	-0.627**	-0.555**	-0.418**	-0.673**	-0.518**	-0.503	-0.472**	-0.678**	1			
LA	0.733**	0.578**	0.507**	0.387**	0.697**	0.376*	0.342	0.610**	0.591**	-0.431**	1		
NB	0.685**	0.527**	0.574**	0.551**	0.666**	0.202ns	0.159ns	0.512**	0.621**	-0.529**	0.459**	1	
PH	0.591**	0.360**	0.552**	0.431**	0.619**	0.012ns	-0.029ns	0.519**	9.572**	-0.437**	0.499**	0.658**	1

ST= Seed Yield per Hectare. PT=Pod Yield per Hectare. SW= Hundred Seed Weight. NS= Number of Seed per Pod. PU=Phosphorus Uptake. PW= Pod Width. PL= Pod Length. NP=Number of Pod per Plant. ND= Number of Nodes per Plant. CGR=Crop Growth Rate. LA=Leaf Area Index. NB=Number of Branches. PH= Plant Height. * = significant df at 5% level. ** = highly significant df at 1% level. ns = not significant.

Table 5: matrix of correlation showing the relationship between growth, and yield characters of lablab in 2021 wet season

	ST	PT	SW	NS	PU	PW	PL	NP	ND	CGR	LA	NB	PH
ST	1												
PT	0.418*	1											
SW	0.414*	0.813**	1										
NS	0.457**	0.567**	0.565**	1									
PU	0.539**	0.810**	0.825**	0.577**	1								
PW	0.542**	0.347*	0.307ns	0.291ns	0.371**	1							
PL	0.319ns	0.254ns	0.233ns	0.193ns	0.306ns	0.517**	1						
NP	0.567**	0.796**	0.753**	0.556**	0.807**	0.491**	0.424*	1					
ND	0.515**	0.877**	0.778**	0.651**	0.828**	0.322ns	0.258*	0.784**	1				
CGR	-0.390*	-0.646**	-0.686**	-0.432**	-0.754**	-0.170ns	-0.241*	-0.652*	-0.667**	1			
LA	0.450**	0.731**	0.671**	0.498**	0.648**	0.154ns	0.210ns	0.688*	0.714**	-0.509**	1		
NB	0.303ns	0.601**	0.493**	0.534**	0.606**	0.091ns	0.053ns	0.583*	0.637**	-0.472**	0.508**	1	
PH	0.460**	0.748**	0.598**	0.489**	0.753**	0.240*	0.268*	0.674*	0.698**	-0.596**	0.597**	0.639**	1

ST= Seed Yield per Hectare. PT=Pod Yield per Hectare. SW= Hundred Seed Weight. NS= Number of Seed per Pod. PU=Phosphorus Uptake. PW= Pod Width. PL= Pod Length. NP=Number of Pod per Plant. ND= Number of Nodes per Plant. CGR=Crop Growth Rate. LA=Leaf Area Index. NB=Number of Branches. PH= Plant Height. * = significant df at 5% level. ** = highly significant df at 1% level. ns = not significant.

Table 6: matrix of correlation showing the relationship between growth, and yield characters of lablab in combined seasons

	ST	PT	SW	NS	PU	PW	PL	NP	ND	CGR	LA	NB	PH
ST	1												
PT	0.624**	1											
SW	0.654**	0.697**	1										
NS	0.500**	0.466**	0.482**	1									
PU	0.763**	0.750**	0.750**	0.550*	1								
PW	0.654**	0.517**	0.420**	0.230*	0.392**	1							
PL	0.409**	0.450**	0.320**	0.228**	0.357**	0.662**	1						
NP	0.694**	0.622**	0.651**	0.436**	0.758**	0.399**	0.330**	1					
ND	0.659**	0.663**	0.704**	0.467**	0.737**	0.378**	0.224*	0.611**	1				
CGR	-0.554**	-0.592**	-0.567**	-0.389**	-0.688**	-0.317**	-0.292**	-0.561**	-0.579**	1			
LA	0.554**	0.533**	0.539**	0.237*	0.558**	0.290*	0.185ns	0.621**	0.628**	-0.413**	1		
NB	0.532**	0.510**	0.541**	0.404**	0.605**	0.148*	0.075ns	0.578**	0.579**	-0.461**	0.501**	1	
PH	0.601**	0.516**	0.589**	0.351**	0.671**	0.179ns	0.170*	0.574**	0.590**	-0.511**	0.527**	0.620**	1

ST= Seed Yield per Hectare. PT=Pod Yield per Hectare. SW= Hundred Seed Weight. NS= Number of Seed per Pod. PU=Phosphorus Uptake. PW= Pod Width. PL= Pod Length. NP=Number of Pod per Plant. ND= Number of Nodes per Plant. CGR=Crop Growth Rate. LA=Leaf Area Index. NB=Number of Branches. PH= Plant Height. * = significant df at 5% level. ** = highly significant df at 1% level. ns = not significant.

Table 7: Multiple regression coefficient of seed yield in regards to growth and yield characters of lablab. (3 years pooled)

Variables	Coefficient	Standard Error	t-value	p-value
Plant height	0.015	0.292	0.163	0.871ns
Number of branches	-0.096	0.944	-1.192	0.237ns
Leaf area index	-0.058	3.011	-0.658	0.513ns
Number of pods per plant	0.700	0.534	6.831	0.000*
Number of nodules per plant	0.178	1.045	1.364	0.177ns
Pod yield per plant	0.154	0.040	1.356	0.180ns

ns = Non-significant. *= Significant 5% level of probability