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Influence of Laterite Soil on the Growth and Yield of Cowpea (*Vigna unguiculata* L.) Accessions in Nasarawa State

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Abstract: This study was conducted to determine the influence of laterite soil on the growth and yield of cowpea accessions. Five different cowpea accessions (TVU-1335, TVU-11530, TVU-997, TVU-10778 and TVU-4593) were sourced from International Institute of Tropical Agriculture (IITA) in Ibadan, Oyo State. Three different layer of Laterite soil, Organic layer (LI), Upper mineral horizon (L2), Leached horizon (L3) and Loamy soil (L0) as control were collected from Akurba, Lafia, Nasarawa State. These treatments were measured into 60 bags of 20 kg each and were laid out in a (RCBD) with three replications in the Department of (PSB), Fulafia. Seed rate was 3 seeds per planting bag at a depth of 2.5 to 3 cm. Data were collected for some growth and yield parameters such as Number of days to seed germination (NDSG), % Seeds Germination (%SG), Plant height at maturity (PHATM), Number of days to flower formation (NDFF), Number of days to pod formation (NDPF), Number of days to pod maturity (NDPM), Number of pods per plant (NPP), Number of seeds per pod (NSPP), Number of leaves per plant (NOLPP), Leaf area per plant (LAPP) and Stem girth (S.G). TVU-1335 (L3) was observed to have the highest (NDSG) of 6.13. %SG was observed highest in (L1) with 97.78%, PHATM was highest at (L0) with 18.64cm, NDFF was observed highest at (L2) with 48.47DAP, NDPF was registered highest at (L2) with 51.80DAP, NDPM was observed highest at (L2) with 61.93DAP, NPP was observed highest at (L0) with 34.12DAP, LAPP was also observed highest at (L1) with 63.17DAP, NOLPP was noticed to be highest in (L3) with 55.87DAP, at (L2) NSPP was higher with 12.42 and S.G was observed highest at (L0) with 3.02 cm. Data collected were subjected to a two-way (ANOVA) and LSD was used to separate mean difference at $p \leq 0.05$ level of significant. The result indicates that, none of the cowpea accession is significantly superior in terms of growth and yield performance on lateritic soils experiment.

Keywords: Laterite, cowpea, soil, growth, yield

Introduction

Cowpea (*Vigna unguiculata* L.) is a grain legume member of the *Fabaceae* [1, 2]. It is one of the major sources (10-20%) of the dietary protein in many of the poorest countries in the world [3, 4, 5]. The Consultative Group for International Agricultural Research (CGIAR) is targeting cowpea, for yield and agronomic improvement by estimate about 11.5 hectares of land are used to produce over 95% of the 5.4 million tons of cowpea globally, especially in the semiarid regions of West and Central Africa [5].

Despite increasing advances in the yields and stress tolerance of cowpea over the years, there are many varieties which are low yielding and are susceptible to a range of abiotic and biotic stresses [6]. Lateritic soils are described as product of highly weathered material, under tropical and subtropical conditions, rich in secondary oxides of iron, aluminum or both [7]. They are nearly void of bases and primary silicates, but may contain amounts of quartz or kaolinite. Also, the lateritic soils are either hard or capable of hardening on exposure to wetting and drying. Furthermore, the lateritic soils are composed of a wide variety of red, brown, and yellow fine-grained residual soils of light texture, as well as nodular gravels and cemented soils [8, 9].The aim of the study was to investigate the growth and yield assessment of cowpea accessions in a typical lateritic soil.

Materials and Methods

Source of planting materials

Five different cowpea accessions namely TVU-10778, TVU-1335, TVU-11530, TVU-997, and TVU-4593 were sourced from International Institute of Tropical Agriculture (IITA).

Soil collection

Three different layers of laterite soil were collected from Akurba, Lafia, Nasarawa State using a hand augar and sample extractor with accessories [7]. The soil depths included 1 – 1.5 m, 1.6 – 2.0 m and 2.5 – 3.0 m. The first layer (1 – 1.5 m depth) known as organic layer of the laterite soil was label (L1), the second layer (1.6 – 2.0 m depth) known as the upper mineral horizons was labeled (L2), the third layer (2.5 – 3.0 m depth) known as Leached horizons was label (L3) and a Loamy soil was label (L0) as the Control respectively. The treatments were measured into 60 bags of 20 kg each and were arranged randomly at a plot in the Botanical Garden of Federal University of Lafia.

Experimental design

The experiment was laid out in a Randomize Complete Block Design (RCBD) with 3.

Data analysis

Data collected were analyzed using Genstat Discovery Edition version 17 Software. Two way Analysis of Variance (2-way ANOVA) test was used to separate the mean differences at $p \leq 0.05$ level of significance.

Results and Discussions

The result for number of days to seed germination in laterite soil are shown in Table 1, Plates 1–2. Similarly, the results for percentage seed germination of cowpea accessions in laterite soil; plant height at maturity of cowpea accessions in laterite soil; number of leaves per plant of cowpea accessions in laterite soil; leave area per plant of cowpea accessions in laterite soil; number of days to flower formation of cowpea accessions in laterite soil; stem girth of cowpea accessions in laterite soil; number of days to pod formation (NDPF) of cowpea accessions; number of days to pod maturity of cowpea accessions in laterite soil are presented on Tables 2 – 9, respectively. Table 10 and Plate 3 depict the number of pods per plant (NOPP) of cowpea accessions in laterite soil, while Tables 11 and 12 display the number of seeds per pod of cowpea accessions in laterite soil and Pearson correlation, respectively.

Table 1: Mean effect of laterite treatments on number of days to seed germination

Accessions	T0	T1	T2	T3	Mean	
TVU-1335	3.33	4.00	4.67	7.00	4.75	
TVU-11530	3.67	5.00	5.67	5.33	4.92	
TVU-997	4.00	5.00	6.00	6.00	5.25	
TVU-10778	3.00	4.00	4.00	5.67	4.17	LSD_V =2.31
TVU-4593	4.00	4.67	5.00	6.67	5.09	
Mean	**3.60**	**4.53**	**5.07**	**6.13**		
			LSD_T = 1.21			

T1= first laterite layer (1.0-1.5 m depth); T2= Second layer (1.6-2.0 m depth); T3= Third layer (2.5-3.0 m depth); T0= control (Loamy Soil); p-value $\leq$ 0.05

Plate 1: Cowpea TVU-997 accession growing on laterite treatment L1 at 14 days after germination

Plate 2: Pods and seeds of TVU-997 accession

Table 2: Mean effect of laterite treatments on %seed germination of cowpea accessions 14DAP

Accessions	T0	T1	T2	T3	Mean	
TVU-1335	88.90	88.90	100.00	100.00	94.45	
TVU-11530	88.90	100.00	88.90	100.00	94.95	
TVU-997	77.77	100.00	88.90	77.80	86.12	LSD_V = 24.55
TVU-10778	83.35	100.00	88.90	100.00	93.06	
TVU-4593	100.00	100.00	100.00	88.90	97.23	
Mean	87.78	97.78	93.34	93.34		
		LSD_T = 23.50				

T1= first laterite layer (1.0-1.5 m depth); T2= Second layer (1.6-2.0 m depth); T3= Third layer (2.5-3.0 m depth); T0= control (Loamy Soil); p-value $\leq$ 0.05

Table 3: Mean effect of laterite treatments on plant height at maturity of cowpea accessions

Accessions	T0	T1	T2	T3	Mean	
TVU-1335	20.37	11.20	18.47	10.43	15.12	
TVU-11530	19.57	22.30	15.67	19.37	19.23	
TVU-997	16.43	7.67	9.87	18.80	13.19	LSD_V = 6.80
TVU-10778	13.55	12.77	11.53	6.53	11.09	
TVU-4593	23.28	20.83	16.73	18.77	19.90	
Mean	18.64	14.95	14.45	14.78		
			LSD_T = 12.51			

T1= first laterite layer (1.0-1.5 m depth); T2= Second layer (1.6-2.0 m depth); T3= Third layer (2.5-3.0 m depth); T0= control (Loamy Soil); p-value $\leq$ 0.05

Table 4: Number of leaves per plant of cowpea accessions in laterite soil

Accessions	T0	T1	T2	T3	Mean	
TVU-1335	59.3	52.0	49.7	52.7	53.42	
TVU-11530	41.0	37.3	55.7	43.3	44.33	
TVU-997	44.0	54.7	52.0	50.7	50.33	LSD_V = 10.09
TVU-10778	61.7	54.7	48.0	66.3	57.67	
TVU-4593	41.7	48.7	41.3	66.3	49.50	
Mean	49.53	49.47	49.33	55.87		
			LSD_T = 9.02			

T1= first laterite layer (1.0-1.5 m depth); T2= Second layer (1.6-2.0 m depth); T3= Third layer (2.5-3.0 m depth) T0= control (Loamy Soil); p-value $\leq$ 0.05

Table 5: Mean effect of laterite treatments on leave area per plant of cowpea accessions 60DAP

Accessions	T0	T1	T2	T3	Mean	
TVU-1335	54.6	64.6	56.6	58.3	58.56	
TVU-11530	57.6	77.8	51.3	72.0	64.70	
TVU-997	53.2	62.9	68.6	49.3	58.49	LSD_V = 11.11
TVU-10778	63.1	54.8	58.1	61.2	59.27	
TVU-4593	58.4	55.7	56.8	52.9	55.95	
Mean	57.38	63.17	58.28	58.74		
		LSD_T = 9.94				

T1= first laterite layer (1.0-1.5 m depth); T2= Second layer (1.6-2.0 m depth); T3= Third layer (2.5-3.0 m depth); T0= control (Loamy Soil); p-value ≤ 0.05

Table 6: Mean effect of laterite treatments on number of days to flower formation of cowpea accessions

Accessions	T0	T1	T2	T3	Mean	
TVU-1335	49.00	62.00	57.00	40.33	52.08	
TVU-11530	39.33	48.00	48.67	52.67	47.17	
TVU-997	40.67	33.33	34.00	50.67	39.67	LSD_V = 31.13
TVU-10778	42.50	44.67	49.00	32.33	42.13	
TVU-4593	45.00	49.67	53.67	57.33	51.42	
Mean	43.30	47.53	48.47	46.67		
		LSD_T = 15.49				

T1= first laterite layer (1.0-1.5 m depth); T2= Second layer (1.6-2.0 m depth); T3= Third layer (2.5-3.0 m depth); T0= control (Loamy Soil); p-value ≤ 0.05

Table 7: Mean effect of laterite treatments on stem girth at 60DAP of cowpea accessions

Accessions	T0	T1	T2	T3	Mean	
TVU-1335	2.98	2.85	2.77	3.15	2.94	
TVU-11530	2.82	2.64	3.40	2.73	2.89	
TVU-997	3.00	3.21	3.00	2.47	2.92	LSD_V = 0.35
TVU-10778	2.90	2.75	2.88	3.13	2.92	
TVU-4593	3.39	2.93	2.74	2.65	2.93	
Mean	3.02	2.88	2.96	2.83		
		LSD_T = 0.31				

T1= first laterite layer (1.0-1.5 m depth); T2= Second layer (1.6-2.0 m depth); T3= Third layer (2.5-3.0 m depth); T0= control (Loamy Soil); p-value ≤ 0.05

Table 8: Mean effect of laterite treatments on number of days to pod formation of cowpea accessions

Accessions	T0	T1	T2	T3	Mean	
TVU-1335	53.00	63.67	59.00	42.67	54.58	
TVU-11530	42.00	51.67	53.67	58.67	51.50	
TVU-997	44.00	36.33	36.00	53.67	42.50	LSD_V = 29.20
TVU-10778	45.00	52.00	52.67	35.00	46.17	
TVU-4593	48.50	53.33	57.67	49.07	52.14	
Mean	46.50	51.40	51.80	47.82		
		LSD_T = 16.09				

T1= first laterite layer (1.0-1.5 m depth); T2= Second layer (1.6-2.0 m depth); T3= Third layer (2.5-3.0 m depth); T0= control (Loamy Soil); p-value ≤ 0.05

Table 9: Mean effect of laterite treatments on number of days to pod maturity of cowpea accessions

Accessions	T0	T1	T2	T3	Mean	
TVU-1335	63.00	72.67	65.67	48.67	62.50	
TVU-11530	55.67	63.33	65.33	69.33	63.42	
TVU-997	57.67	42.67	42.00	64.33	51.67	LSD_V = 30.63
TVU-10778	58.00	66.00	67.67	43.67	58.84	
TVU-4593	61.25	61.67	69.00	70.33	65.56	
Mean	59.12	61.27	61.93	59.27		
		LSD_T = 9.34				

T1= first laterite layer (1.0-1.5 m depth); T2= Second layer (1.6-2.0 m depth); T3= Third layer (2.5-3.0 m depth; T0= control (Loamy Soil); p-value ≤ 0.05

Table 10: Mean effect of laterite treatments on number of pod per plant of cowpea accessions

Accessions	T0	T1	T2	T3	Mean	
TVU-1335	36.33	35.33	34.67	21.00	31.83	
TVU-11530	37.67	39.33	28.00	21.00	31.50	
TVU-997	36.33	21.00	12.33	29.00	24.67	LSD_V = 18.96
TVU-10778	25.00	26.00	27.00	23.00	25.25	
TVU-4593	35.25	21.00	38.00	28.67	30.73	
Mean	34.12	28.53	28.00	24.53		
		LSD_T = 25.88				

T1= first laterite layer (1.0-1.5 m depth); T2= Second layer (1.6-2.0 m depth); T3= Third layer (2.5-3.0 m depth); T0= control (Loamy Soil); p-value ≤ 0.05

Plate 3: Pods of TVU-10778 accession on treatment L2

Table 11: Mean effect of laterite treatments on number of seeds per pod of cowpea accessions after harvest

Accessions	T0	T1	T2	T3	Mean	
TVU-1335	12.00	11.33	13.67	11.67	12.17	
TVU-11530	12.00	11.33	12.00	11.00	11.58	
TVU-997	12.00	12.00	11.67	11.67	11.83	LSD_V = 1.57
TVU-10778	13.00	11.67	13.33	11.67	12.42	
TVU-4593	10.00	11.33	9.67	11.00	10.50	
Mean	11.80	11.53	12.07	11.40		
		LSD_T = 1.41				

T1= first laterite layer (1.0-1.5 m depth); T2= Second layer (1.6 -2.0 m depth); T3= Third layer (2.5-3.0 m depth); T0= control (Loamy Soil); p-value ≤ 0.05

Table 12: Relationship between the growth and yield parameters

Parameter	NDSG	% SG	NDFF	NDPF	NDPM	NP/P	NS/P	PHATM (cm)	NSPP	NDSG	NOLPP
% SG	0.115										
NDFF	-0.260*	-0.136									
NDPF	-0.274*	-0.113	0.982**								
NDPM	-0.333**	-0.113	0.945**	0.968**							
NP/P	-0.359**	-0.060	0.601**	0.603**	0.624**						
NS/P	-0.233*	-0.056	0.762**	0.776**	0.780**	0.595**					
PHATM (cm)	-0.441**	-0.220	0.439**	0.469**	0.502**	0.440**	0.594**				
NSPP	-0.128	0.113	-0.137	-0.153	-0.126	-0.119	0.011	-0.149			
NDSG	0.038	0.004	-0.080	-0.097	-0.128	-0.022	0.063	0.049	0.124		
NOLPP	0.085	-0.137	-0.163	-0.180	-0.157	-0.317	-0.148	-0.295*	0.299*	0.068	
LAPP	0.142	-0.080	-0.079	-0.066	-0.121	-0.164	-0.103	0.002	0.032	0.048	-0.222

* = Correlation is significant at the 0.05 level (2-tailed); ** = Correlation is significant at the 0.01 level (2-tailed).

This study shows that the highest number of days to seed germination was 5.25 as observed in TVU-997 accession with treatment T3 (Leaching horizons). This report is not synonymous with the report of [10] on the analysis of soybean germination, emergence, and prediction of a possible northward expansion of the crop under climate change. They reported that seed germination and seedling emergence under field conditions was slow as it took 8 days after sowing (DAS) to reach the maximum rate i.e. 100%. Seedling emergence started at 5 Days after sowing and reached the maximum level (88%) at 14 Days after sowing showing a gradual increase in emergence rate over time.

TVU-4593 accession with treatment T1 (Organic layer) was observed at 6 Days after planting to have the highest percentage of seed germination of 97.23. The result is not in conformity with the work of [11] on the yield performances of tomatoes (*Lycopersicum esculentum*) on organic manure buffered lateritic soils. They showed that sprouting commenced at the second week of planting. Some germinated at five days while others germinated seven to eight days, the results revealed that seed germination percentage was higher in sandy-loam buffered soil, 92.5%, followed by lateritic buffered soil, 87.5%. Ansa, working on elephant grass on lateritic soil also opined loamy soil at the best in terms of number of days to germination [12].

It was seen generally that the T2 in terms of plant height yielded/performed best on loamy when compared with the T3. This is in agreement with the work done by [13] in Napier-4 fodder which had better growth, development and yield on loamy soils compared with sandy soils. This also corroborates with the report of [12] who observed that plant height increment, number of leaves, leaf length, leaf area, number of tillers, fresh weight and dry weight yield were markedly higher in elephant grasses grown on loamy soil compared with the laterite and sandy soils.

The highest observed mean number of days to flower formation in this study was 52.08 in TVU-1335 accession with treatment T2 and it is not significantly different from other accessions. Similar trend was observed when considering the yield component of the study. This observation is not in agreement with that of [14] which shows that the average number of days to first flower initiation (DFFI) ranged from 29.16 to 41.37 days while days to 50% flowering (DFF) ranged between 33.11 and 44.29 days in their research on inheritance of early maturity in some cowpea (*Vigna unguiculata* L. walp.) genotypes under rain fed conditions in Northern Ghana.

Parameters like number of pods/plant, number of days to pod maturity and mean number of pod per plant had similar observations. This probably may be because of the presence of organic matter in loamy soil [15, 16] and higher moisture retention in both loamy and laterite soils [17, 18]. Adegbite [18] reported in their research on the comparative evaluation of varieties of cowpea and its effect on fertility status of lateritic soil of Landmark University that, IAR 2.5.6 produced the highest number of pods per plant (NOPPP), showing higher significance ($P<0.05$) than variety IAR48.

There was varietal difference in response to the growth and yield of the crop in laterite soil. For example, in terms of the number of seeds per plant, TVU-10778 had the highest though comparable with TVU-4593. However, there was no significant difference among the treatment. This result is not similar to that observed by some researchers [18, 19]. They reported that the number of seeds per pod (NOSPP) for variety IAR48 was significantly higher ($P<0.05$) than variety IAR, it also showed observable higher numerical difference.

In all parameters taken and recorded laterite soil produced cowpea that had statistically similar or very little difference from those planted on loamy soil. This shows that production of cowpea may not be adversely influenced if grown on lateritic soils. Patil & Sheelavantar reported that laterite soil could be used in the production of crops [20].

In breeding correlation matrix is a prominent approach for the judgment of degree of the association between two or more variables, is supported by [13]. For superior genotype's selection programme consideration of correlation matrix can be a great scale of measurement. The highest significant positive correlation observed between NDPF and NDFF agrees with work done by [21] who working with Bambara nuts opined that there was a positive correlation between number of flowers per plant and the number of seeds per plant. However, significant negative correlation was observed between NDSG and other parameters such as NPP, NDPM, NDPF and NDFF.

Conclusion

The study shows that the growth and yield values of cowpea grown on laterite soil were favorably comparable to the cowpea grown on loamy soil. Loamy soil recorded the least values in most growth and yield parameters determined. For example it shows least number of days to seed germination, least percentage seeds germination, least leaf area per plant, least number of days to flower formation, least number of days to pod formation, and least number of days to pod maturity. However, the highest recorded values of laterite treatment was observed in T2 (Upper mineral horizons) and it shows highest number of days to flower formation, number of days to pod formation, number of days to pod maturity and number of seed per pod. Loamy soil did not record cowpea that where obviously different in measurement than the ones planted on lateritic soils. Laterite soil can therefore support the production of cowpea.

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