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Effect of phosphorus fertilizer on growth, yield and crude protein content of cowpea (*Vigna unguiculata* [L.] Walp) in Nigeria

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ABSTRACT

Objective: To evaluate the response of two cowpea varieties to phosphorous fertilizer (P) levels so as to determine P-fertilizer recommendations for the Northern Guinea Savanna agroecological zone.

Methodology and results: Treatments of two cowpea varieties SAMPEA 7 and SAMPEA- 6 (Local) and three P-levels (0, 37.5 and 75 kg P/ha) using single super phosphate (18% $P_2 0_{5)}$ were laid out in a factorial combination in a randomized complete block design with four replications in Samaru. Generally, in the two years, phosphorous application significantly increased growth parameters assessed. Plant height was increased by 63 and 35.9% at 8 weeks after sowing (WAS) in 2001 and 2002, respectively over compared to the control when the highest P level (75kg P/ha) was applied. SAMPEA – 6 (local) produced more leaves and higher dry matter yield than SAMPEA – 7 at all the sampling periods. The results also indicated that grain yields and crude protein content realized with 35.5kg P/ha did not differ significantly from that of 75kg P/ha.

Conclusion and application of findings: Most farmers in Africa do not have access to P-fertilizer, there is therefore need to select cowpea varieties that can still produce good yield under low soil P or those with high P use efficiency as a low input approach to addressing this constraint. Based on these trials, a significant interaction between P-fertilizer and cowpea varieties on grain yield was noted which suggests that P-fertilizer recommendation for cowpea should be location specific. The application of 37.5kg P/was the most economical level for maximum grain yield and crude protein content. Therefore, when P-fertilizer is available, SAMPEA – 7 is recommended, while SAMPEA – 6 (local) will perform better without P-fertilizer and will give a higher return when P is applied.

Key words: Cowpea, fertilizer, phosphorus, yields.

INTRODUCTION

Phosphorus (P) is among the most needed elements for crop production in most tropical soils, which tend to be P deficient (Adetunji, 1995). The deficiency can be acute in some soils of the Savanna zone of Western Africa to the extent that plant growth ceases as soon as the P stored in the seed is exhausted (Mokwunye *et al*., 1986). P deficiencies primarily result from either inherent low levels of soil P or depletion through cultivation.

Phosphorus, although not required in large quantities, is critical to cowpea yield because of its multiple effects on plant nutrition (Muleba & Ezumal, 1985). Phosphorus does not only increase seed yields but also nodulation (Luse *et al*., 1975; Kang & Nangju, 1983) and thus N fixation. Phosphorus application influences the contents of other nutrients in cowpea leaves (Kang & Nangju, 1983) and seed (Omueti & Oyenuga, 1970). Kudikeri *et al.* (1973) reported an increase of about 5% seed protein content of cowpea as a result of P application. Singh & Jain (1966) observed that P application increased the number of branches, dry weight of shoots and nodule number per cowpea plant, but other characters were unaffected. Phosphorus has also been reported to increase the number of leaves and fruits per plant, as well as earliness of flowering and yields (Kudikeri *et al*., 1973). Application of P fertilizer is therefore recommended for cowpea production on deficient soils (Sellschop, 1962).

However, inorganic P-fertilizers are often expensive and not readily available to resource – poor farmers. Furthermore, P-fertilizer can be fixed into forms unavailable to plants by Fe and Al oxides found in tropical soils (Sample *et al*., 1980). Application of inorganic P fertilizers may thus not be the most viable option to alleviate P – deficiency for improved cowpea production. Effects of P on nodulation (Ankomah *et al*., 1995) and yield (Jain *et al*., 1986; Tenebe *et al*., 1995; Sanginga *et al*., 2000) of cowpea have been previously reported to vary with genotypic. However, the mechanisms by which cowpea varieties exhibit differential responses to P supply are not yet completely understood.

There have been conflicting reports of P recommendations for cowpea production in the Northern Guinea Savanna agroecological zone. Gang *et al*. (1970) and Yusuf (1987) obtained good cowpea grain yield with application of 37 and 40kg P/ha respectively. However, irrespective of P source, Agboola & Obigbesan (1977) reported higher grain yield when 30kg P/ha was applied.

This study was carried out to evaluate the response of two cowpea varieties to P application so as to determine suitable recommendations for the Northern Guinea Savanna agroecological zone. Samaru.

MATERIALS AND METHODS

Two field trials were conducted during the rainy seasons (July to October) of 2001 and 2002 in Samaru (11^0 11'N 7º 38'E) in the Northern Guinea Savanna ecological zone of Nigeria to assess the effect of P fertilizer application on growth, yield and crude protein content of cowpea Seeds of two cowpea varieties (SAMPEA – 6 and SAMPEA – 7) were obtained from the Institute for Agricultural Research (IAR) Zaria, Samaru.

Analysis of soils at the experimental site in both years indicated that the field was low in pH, total nitrogen and available phosphorus. Treatments consisted of two cowpea varieties (SAMPEA – 6 and SAMPEA – 7), and three P levels (0, 37.5 and 75kg Pha^{-1}), using single super phosphate (18% P_20_5). Factorial combinations of all treatments were laid out in a randomized complete block design (RCBD) with four replications. Each plot consisted of six ridges of 4m long and 0.75m between ridges. Three seeds of each variety were planted per hill and later thinned to two plants per hill two weeks after planting giving a population of 106,666 plants per hectare. The phosphorus fertilizer was band-applied at planting to minimize P – fixation.

Observations made included plant height, leaf area, total dry matter (DM) per plant, number of branches, leaves and grain yield. Five grains of the harvested seeds from each plot was ground into fine paste for determination of crude protein content. Total nitrogen content of the paste was obtained by the micro – kjeldhal method and the value multiplied by a factor of 6.25 to get the crude protein content. Data collected were subjected to analysis of variance and means separated using LSD.

RESULTS

In the two years, P application had no significant influence on cowpea emergence (Table 1). However, the effect was significant on leaf area per plant of cowpeas except at 4WAS in 2001 (Table 1). Cultivar SAMPEA – 6 produced higher leaf area than SAMPEA – 7 throughout the period of sampling in both years. Generally, increasing P – level increased cowpea leaf area per plant significantly the throughout the experimental period.

The effect of P level on plant height was not significant at 4 WAS in the two years, however, it was significant (P = 0.05) for the remaining periods of sampling, increasing with increase in P levels (Table 2).

In 2001, plant height was not significantly affected by P – level at 4WAS, but, in 2002, SAMPEA – 6 had taller plants than SAMPEA – 7. This trend was reversed at 8 and 10WAS when SAMPEA – 7 had significantly taller plants than SAMPEA – 6.

Table 1: Effect of P – level on emergence percentage and leaf area of cowpea varieties at Samaru in 2001 and 2002 wet seasons.

Seed – size	% emergence		Leaf area/plant (m²)							
			4WAS²		6WAS		8WAS		10WAS	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
P – level¹										
0	79. 33	67.13	.07	.08b	.32b	.36b	.54b	.74b	.35c	.37c
37. 5	78. 39	76. 62	.08	.10ab	.34ab	.40a	.57ab	.87a	.50b	.46b
75. 0	77. 67	76. 85	.08	.11a	.36a	.50a	.60a	.89a	.57a	.47a
L. S. D. (5%)	NS	NS	NS	.03	.03	.06	.04	.12	.03	.08
Variety										
SAMPEA – 6	75. 26	72. 84	.06	.10	.33a	.42	.53a	.97a	.47a	.48a
SAMPEA – 7	78. 33	74. 23	.07	.09	.26b	.42	.32b	.70b	.33b	.39b
L. S. D. (5%)	NS	NS	NS	NS	.07	NS	.11	.09	.11	.12
Interaction										
P × Var	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

¹kg pha^{-1}; ²weeks after sowing (WAS); 2001/2002 = experimental year;
Means in the same column followed by the same letter (s) are not significantly different (P≤0.05)

Table 2: Effect of P – level on plant height of cowpea varieties at Samaru jn 2001 and 2002 wet seasons.

	Plant height (m)							
Seed size	**4 WAS²**		**6 WAS**		**8 WAS**		**10 WAS**	
	2001	2002	2001	2002	2001	2002	2001	2002
P – levels¹								
0	.16	.16	.42b	.45b	.92b	.92c	1.00c	1.10b
37. 5	.16	.17	.44a	.45b	.93b	1.12b	1.15b	1.14ab
75. 0	.16	.17	.52a	.47a	1.50a	1.25a	1.23a	1.27a
L. S. D. (%)	NS	NS	0.01	.02	.03	.23	.11	.15
Variety								
SAMPEA – 6	.16	.17a	.49a	.47	.98	.94b	1.37a	1.06b
SAMPEA – 7	.15	.16b	.42b	.44	.95	1.26a	1.09b	1.32a
L. S. D. (5%)	NS	.01	.01	NS	NS	.09	0.19	.09
Interaction								
P × Var	NS	NS	NS	NS	NS	NS	NS	NS

¹kg pha^{-1}; ²weeks after sowing (WAS); 2001/2002 = experimental year;
Means in the same column followed by the same letter (s) are not significantly different (P≤0.05)

Significant increase in the number of branches was recorded at 4WAS in 2002, and at 8 and 10WAS in 2001 in both varieties. The difference between the two varieties was not consistent for the sampling weeks and years of the experiment. The leaf number and dry matter yield/plant increased significantly with levels of P – fertilizer for all the sampling periods in the two trials (Tables 4 and 5). SAMPEA – 6 produced more leaves and higher dry matter yield than SAMPEA – 7 at all the sampling periods.

Table 3: Effect of P – level on number of branches/plant of cowpea varieties at Samaru in 2001 and 2002 wet seasons.

Number of branches/plant								
Seed size	**4 WAS[2]**		**6 WAS**		**8 WAS**		**10 WAS**	
	2001	**2002**	**2001**	**2002**	**2001**	**2002**	**2001**	**2002**
P – levels[1]								
0	2.56	3.10b	5.21	5.53	8.04c	5.64	13.11b	6.00
37. 5	2.56	3.77ab	5.23	5.81	10.78b	5.65	14.00b	6.70
75. 0	2.17	3.92a	5.40	5.89	13.39a	6.17	15.10a	6.80
L. S. D. (%)	NS	.80	NS	NS	2.71	NS	1.00	NS
Variety								
SAMPEA – 6	2.22	3.94a	4.19a	6.33a	7.89a	6.71a	9.07a	7.19b
SAMPEA – 7	2.33	3.19b	5.69b	5.15b	14.52a	4.93b	19.33a	3.85a
L. S. D. (5%)	NS	.35	0.69	.50	0.04	.54	2.28	0.37
Interaction								
P × Var	NS	NS	NS	NS	NS	NS	NS	NS

[1]kg pha^{-1}; [2]weeks after sowing (WAS); 2001/2002 = experimental year;
Means in the same column followed by the same letter (s) are not significantly different (P≤0.05)

Table 4: Effect of P – level on number of leaves/plant of cowpea varieties at Samaru in 2001 and 2002 wet seasons.

Number of leaves/plant								
Seed size	**4 WAS[2]**		**6 WAS**		**8 WAS**		**10 WAS**	
	2001	**2002**	**2001**	**2002**	**2001**	**2002**	**2001**	**2002**
P – level[1]								
0.0	22.85b	84.33	84.33b	125.83b	160.50	240.86b	125.26b	125.54b
37.5	23.97ab	90.33	90.33ab	139.97ab	161.67	278.90ab	141.06ab	130.39ab
75.0	25.32a	95.11	95.11a	149.74a	166.39	297.83a	160.50a	137.96a
L. S. D. (5%)	2.40	NS	10.20	20.89	NS	50.67	25.20	10.00
Variety								
SAMPEA – 6	28.56a	50.83a	98.56a	173.36a	198.48a	379.96a	185a	164.34a
SAMPEA – 7	19.53b	34.80b	81.11b	103.67b	129.89b	167.46b	99b	95.58b
L. S. D. (5%)	2.67	3.90	11.37	21.12	28.32	42.0	89.00	19.53
Interaction								
P × Var	NS	NS	NS	NS	NS	NS	NS	NS

[1]kg pha^{-1}; [2]weeks after sowing (WAS); 2001/2002 = experimental year;
Means in the same column followed by the same letter (s) are not significantly different (P≤0.05)

Grain yield/ha and crude protein content of cowpea seed increased significantly ($P \leq 0.01$) with increased rate of P. This increase was consistent for the two characters and for both years (Table 6). SAMPEA – 7 consistently produced higher grain yield (2.6 and 2.5 tons/ha for 2001 and 2002, respectively) while SAMPEA – 6 produced 1.6 and 1.3 tons/ha for 2001 and 2002, respectively. Crude protein content for the two cowpea lines was statistically at par with each other.

There was significant interaction between P level and cowpea varieties on grain yield in the two years (Table 7). It was observed that application of 75kg P/ha to SAMPEA – 7 produced grain yield, which is statistically at par with yield from plots fertilized with 37.5kg/ha in 2001 and 2002. Response of SAMPEA – 6 to the applied P, on the other hand was not significant ($P \geq 0.05$).

Table 5: Effect of P – level on total dry matter (D.M) yield/plant of cowpea varieties at Samaru in 2001 and 2002 wet seasons.

	Total dry matter (D.M) yield/plant							
Seed size	**4 WAS[2]**		**6 WAS**		**8 WAS**		**10 WAS**	
	2001	**2002**	**2001**	**2002**	**2001**	**2002**	**2001**	**2002**
P – level[1]								
0.0	3.85	4.98b	19.48	23.82b	41.35b	58.90b	44.62c	51.11b
37.5	3.93	6.1ab	20.43	26.95ab	44.26a	69.08ab	45.83b	60.10a
75.0	4.13	6.33a	21.12	32.39a	44.97a	70.71a	54.17a	63.06a
L. S. D. (5%)	NS	1.30	NS	7.17	3.20	1.50	8.30	6.01
Variety								
SAMPEA – 6	4.49a	6.63a	20.00	30.55a	47.35	55.84a	52.01a	67.62a
SAMPEA – 7	3.46b	4.98b	18.92	24.88b	39.71	40.90b	40.74b	48.56b
L. S. D. (5%)	0.76	.41	NS	5.20	NS	3.90	7.20	9.06
Interaction								
P × Var	NS	NS	NS	NS	NS	NS	NS	NS

[1]kg pha^{-1}; [2]weeks after sowing (WAS); 2001/2002 = experimental year;
Means in the same column followed by the same letter (s) are not significantly different ($P \leq 0.05$)

Table 6: Effect of P – level on the grain yield and crude protein content of cowpea varieties at Samaru in 2001 and 2002 wet seasons.

Seed size	**Final grain yield (kg ha-1)**		**Crude protein content of the grain (%)**	
	2001	**2002**	**2001**	**2002**
P – level[1]				
0	1894.43b	1294.00b	23.41b	22.96b
37.5	2141.76a	1560.42a	24.96a	24.80a
75.0	2152.42a	1670.47a	24.97a	24.81a
L. S. D. (5%)	240.56	120.47	1.38	1.60
Variety				
SAMPEA – 6	1585.41b	1345.30b	24.60	24.70
SAMPEA – 7	2616.59a	2492.20a	24.83	24.62
L. S. D. (5%)	1005.52	1060.90	NS	NS
Interaction				
P × Var	NS	NS	NS	NS

[1]kg pha^{-1}; 2001/2002 = experimental year;
Means in the same column followed by the same letter (s) are not significantly different ($P \leq 0.05$)

DISCUSSION

The clear response to P application observed in terms of growth and protein content of the two varieties confirms that P is an important nutrient element affecting the yield of cowpea (Anonymous, 1977). The increased grain yield due to P addition may be attributed to increased leaf area, plant height and increased branching. The maximum yield response observed at 37.5kg P/ha was similar to that reported by Yusuf (1987) who observed an optimum level of P for cowpea yield to be 40kg P/ha.

There are, however, differential responses among the cowpea varieties studied. Okeleye & Okelana (1997) also observed significantly increased grain yield and total dry matter for cowpea varieties in response to P application. The observed increase in cowpea grain yield with P application agrees with the results of Luse *et al.* (1975) but contradicts the results of Agboola & Obigbesan (1977) who observed that P application did not significantly increase cowpea yield although it enhanced nodulation and P content of leaf and stem. Omueti & Oyenuga (1970) and Kudikeri *et al.* (1973) recorded significant increase in crude protein content of cowpea with P application.

The significant interaction between P levels and cowpea genotype suggests that P fertilizer recommendation should be specific, as the improved cowpea (SAMPEA – 7) responded well to P application, while the local SAMPEA – 6 did not. The interaction results also revealed that SAMPEA – 6 tends to yield higher than SAMPEA – 7 when both were not fertilized SAMPEA – 7 is an improved variety and will therefore have a higher nutrient requirement than the local SAMPEA – 6 that is more adapted to Samaru soils.

Table 7: Interaction of P – fertilizer and cowpea varieties on grain yield at Samaru in 2001 and 2002 wet seasons.

Phosphorus level (kg Pha^{-1})	2001		2002	
	cv. SAMPEA – 6	cv. SAMPEA – 7	cv. SAMPEA – 6	cv. SAMPEA – 7
0	1740b	1680b	1450b	1440b
37.5	1863ab	2379a	1453b	2026ab
75.0	1868ab	2383a	1458b	2081a
SE (±)	208		196	

Means in the same column followed by the same letter (s) are not significantly different (P≤0.05)

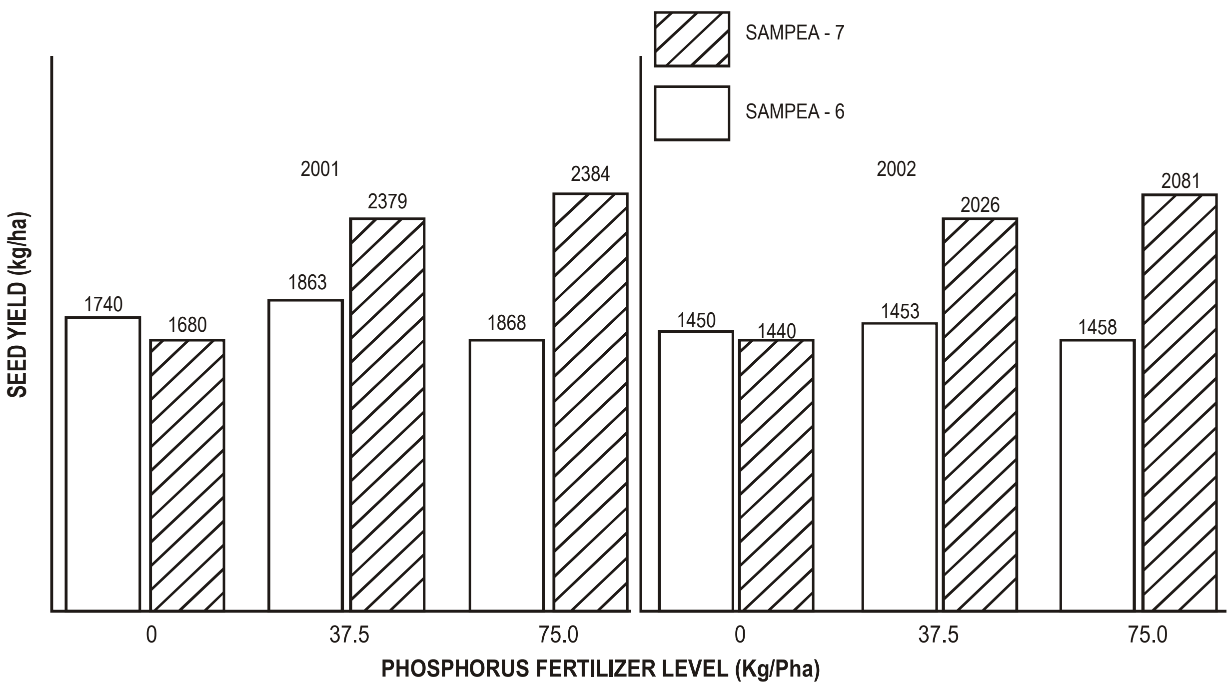

Figure 1: Seed yield of two cowpea lines as influenced by P – fertilizer at Samaru (Northern Guinea Savanna agroecological zone).

REFERENCES

Adetunji MT, 1995. Equilibrium Phosphate Concentration as an estimate of Phosphate needs ?? Maize in some Tropical Alfisols. Tropical Agriculture 72: 285 – 289.

Agboola AA. and Obigbesan GO. 1977. Effect of different sources and levels of P on the Performance and P uptake of Ife – Brown Variety of Cowpea. Ghana Journal of Agricultural Science 10(1): 71 – 75.

Ankomah AB, Zapata F, Hardason G, Danso SKO, 1995. Yield, Nodulation, and N_2 Fixation by Cowpea Cultivars at different Phosphorus levels. Biology and Fertility of Soils 22: 10 – 15.

Anonymous, 1977. Notes on the Cowpea and Grain Legume Research Program, Cropping Scheme Meeting. Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria.

Garg KP, Sharma AK, Thakur BT, 1970. Manuring Cowpea in Studies on effects of different rates of Phosphorus and Molybdenum on the growth, yield of Cowpea and Fodder and residual effect on wheat. Indian J. of Agron. 15: 112 – 117.

Jain VK, Chauhan YS, Jain PC, 1986. Effect of different doses of Phosphorus on Growth, yield and quality of Cowpea (*Vigna unguiculata* [L] Walp). Madras Agricultural Journal 73(4): 199 – 202.

Kang BT. and Nangju D, 1983. Phosphorus Response of Cowpea (*Vigna unguiculata* [L]Walp). Tropical Grain Legume Bulletin 27: 11 – 16.

Kudikeri CB, Patil RV, Karishnamurthy K, 1973. Response of Cowpea Varieties under varying levels of Phosphorus. Mysore J. Agric 7(2): 170 – 177.

Luse RI, Kang BT, Fox RI, Nangju D, 1975. Protein quality in Grain Legumes grown in the lowland humid tropics, with special reference to West Africa, Pages 193 – 201. In Fertilizer use and Protein Production. Xi[th] Colloquium, International Potash Institute, 1975, Ronne – Born – holm, Denmark.

Mokwunye AU, Chien SH, Rhodes E, 1986. Phosphorus reaction with tropical Africa soils, pages 253 – 281. In: Management of Nitrogen and Phosphorus Fertilizers in Sub – Saharan Africa, edited by Mokwunye, A.U and Vlek, P.L.G. Martinus Nijhoff Publishers, Dordrecht, the Netherlands.

Muleba N,Ezumah HC,1985. Optimizing Cultural Practices for Cowpea in Africa. Pages 289 – 295. In: Cowpea Research, Production, and Utilization, edited by Singh, S.R. and Rachie, K.O. John Wiley and Sons Ltd, Chichester, UK.

Okeleye KA. And Okelana MAO, 1997. Effect of Phosphorus Fertilizer on Nodulation, growth, and yield of Cowpea (Vigna Unguiculata) varieties. Indian Journal of Agricultural Science 67 (1): 10 – 12.

Omueti JO. and Oyenuga VA, 1970. Effect of Phosphorus Fertilizer on the Protein and essential components of the ash of groundnut and Cowpeas. West African Biology and Applied Chemistry Journal 13(1): 299 – 305.

Sample EC, Soper RJ, Racz GJ,1980. Reactions of Phosphorus Fertilizers in Soils. Pages 263 – 310 In: the Role of Phosphorus in Agriculture, Edited by Khasawneh, F.E., Sample, E.C. and Kamprath, E.J. American Society of Agronomy, Madison, Wisconsin, U.S.A.

Sanginga N,Lyasse O,Singh BB, 2000. Phosphorus use efficiency and Nitrogen Balance of cowpea breeding lines in a low P soil of the derived Savanna zone in West Africa. Plant and Soil 220: 119 – 128.

Sellschop JPF, 1962. Cowpeas. (*Vigna unguiculata* [L] Wallp). Field Crops Abstracts 15: 259 – 266.

Singh RM, Jain TC, 1966. Effect of Phosphate and Molybdate on the Growth Caracters of Russian Giant Cowpea in: Cowpea: Abstract of World Literature, 1: 46.

Tarilla AGI, Ormond DP, Adedipe NC, 1977. Effect of Phosphorus Nutrition and light intensity on growth and yield components of Cowpea (*Vigna Unguiculata* [L]) Ann. Bot. 41: 75 – 83.

Tenebe VA, 1987. Effect of Sources of Phosphorus on the yield and yield components of Cowpea Varieties. Unpublished M.Sc Thesis, Ahmadu Bello University, Zaria, Nigeria.

Tenebe VA, Yusuf Y, Kaigama BK, Aseime IOE, 1995. The effects of Sources and levels of Phosphorus on the growth and yield of Cowpea (*Vigna unguiculata* [L] Walp) Varieties. Tropical Science 35: 223 – 228.

Yusuf Y, 1987. Effect of P – levels on yield and yield components of Cowpea at Samaru. Cropping Scheme Meeting, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria, Pp. 161.