THE EFFECTS OF SOURCES AND LEVELS OF PHOSPHORUS ON THE GROWTH AND YIELD OF COWPEA (**Vigna unguiculata (L) Walp**) VARIETIES

BY

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own work. It has not been presented before in any previous application for a higher degree.

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CERTIFICATION

This thesis titled "THE EFFECTS OF SOURCES AND LEVELS OF PHOSPHORUS ON THE GROWTH AND YIELD OF COWPEA (Vigna Unguiculata (L) Walp.) VARIETIES" by Vincent Ado TENEBE meets the regulations govering the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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"To accomplish great things,
We must not only act,
But also dream,
Not only Plan,
But also believe"

- Anatole France

And ...

"The great thing
In this World
is not so much
where we are,
But in what direction
we are moving"

- Oliver Wendel Holmes

DEDICATION

TO

The Beginning and
The End
In service to
HUMANITY
For today and
A better tomorrow

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- VINCENT ADO TENEBE (1987).

ABSTRACT

An experiment was conducted at Samaru during the wet season to study the effect of sources and levels of phosphorus on the growth and yield of cowpes (Vigna unguiculata (L) Walp) varieties. The treatments consisted of four cowpea varieties (1696, SVU48, 176B, 339-1); four P-levels (0, 18.5, 37.0, 55.5 kg P_2O_5/ha), and two P-sources (Diammonium phosphate 'DAP', single superphosphate 'SSP').

The study revealed that cowpea growth was better with the use of SSP than DAP. Crop growth and yield increased significantly with increasing P-levels and application of 37 kg P_2O_5/ha gave 54% higher seed yield than the control. No significant yield advantages were obtained with applying higher P-levels. Although 1696 grew more vigorously than the other varieties, it did not produce harvestable yields. SVUI48 yielded and 30%higher than 176B and 339-1 respectively. The interaction effect of P-levels x variety influenced grain yield significantly, while P-sources x variety significantly influenced crop earliness to flowering, number of flowers, pods, seeds and pod weight per plant. Grain yield was significantly and positively correlated with yield components (number of flowers, pods, seeds per plant, 1000- seed weight) and with growth characters (plant height, number of leaves and leaf area per plant.

The study, therefore, confirms the adequacy of the current IAR recommendation of 37 kg P_2O_5ha and reveals the superiority of SSP over DAP for cowpea production in the Nigerian savannas.

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Chapter 1

INTRODUCTION

Cowpea (Vigna unguiculata (L) Walp) is one of the oldest cultivated human food crops. Its dried edible seed for which it is mainly cultivated in most areas contains about 23 to 25 % protein and it is one of the most practical sources of storable and transportable protein, especially in the developing tropical world where animal protein is limited, expensive and not easily stored. The main advantage of cowpea over many other food crops is in the simplicity of its preparation and the multiplicity of its edible forms. It is utilized as grain, leaf or green pod vegetable and as forage.

The production of cowpea is mostly concentrated in the tropical and subtropical developing countries, especially Africa. Worldwide cowpea production in 1981 was estimated at 2.27 million tonnes from 7.7 million hectares. Nigeria and Niger produced 850,000t and 271,000t or 49.3 percent of the total world production (Singh and Rachie, 1985). It is interesting however, to note that though Nigeria is one of the highest producing countries, it also records one of the lowest average yield of less than 200 kg/ha annually. Despite the high-yielding ability of cowpea, low productivity is experienced in most producing countries due to a combination of factors such

as vagaries of weather, insect pests and diseases, and the use of local low-yielding varieties with little or no input of fertilizers and crop protection chemicals (Singh and Rachie, 1985).

Research work has shown that fertilizer use accompanied by adequate protection measures could result in tremendous yields from cowpea. Grain yields of 2,768 kg/ha and 2,879 kg/ha were obtained at Yandev, Benue state and Tumu, Bauchi state, respectively, in 1981 (Anonymous, 1982). Average yields per hectare of 3,457 kg/ha and 3,103 kg/ha were obtained in Madagascar and Trinidad, respectively, in 1975 (Anonymous, 1975).

Many workers have reported the need for phosphorus (P) and its significance on the growth and yields of cowpea. Thus, a rate of 37 kg P_2O_5/ha has been recommended and is now being used, especially in the savanna region of Nigeria (Anonymous, 1977; 1978). Single superphosphate fertilizer (SSP) formed the only source of P on which the recommendation was based. The optimum rate of any nutrient element for a crop may depend on the variety or sources of the element (Terman, 1971).

The need to investigate the optimum levels of P for cowpea production from other phosphatic fertilizers and the need to investigate the varietal responses to these other P sources form the basis for this study. Furthermore,

the Federal Government normally orders for various types and forms of fertilizers for farmers' use. Some conditions may cause the Government to buy forms of phosphatic fertilizers other than SSP, either due to non-availability or cost and other related factors. New varieties are also being periodically released which are potentially higher yielding than the varieties they are meant to replace or complement. These new varieties may also have different P requirements from those of the existing varieties.

The objective of this study, therefore, is to investigate the response of varieties of cowpea to different sources and levels of phosphorus and their interactions.

Chapter 2

LITERATURE REVIEW

2.1 Effects of Phosphorus on the Growth and Yield of Cowpea

As in most other crop plants, phosphorus plays a vital role in the growth and performance of cowpea. Phosphorus has been reported to cause robust overall development of cowpea and generally increased the crop yields (Garg et al., 1977; Remison et al., 1980).

The need for phosphorus in the vigorous growth of cowpea is evident from the various characteristic developments that are common with cowpea growing under low or non-availability of phosphorus. Pandy (1968) observed that cowpea grown in sandy soils low in P was stunted and had small dark-green leaves with decrease in the protein N-content in all parts of the plant. Similarly, Kang and Nangju (1983) reported that cowpea plants grown in soils with low or no P were stunted, slightly chlorotic and had smaller leaves than those grown under adequate P nutrition. It is not surprising, therefore, that the low P content of the semi-arid soils has been reported to be a great limiting factor to the growth and yields of cowpea in the region (Anonymous, 1983).

Although some workers have reported that P had no significant effect on cowpea, (Johnson and Evans, 1975), more have reported the significant and yield

boosting effects of phosphorus on the crop. Gill *et al.* (1971) reported that phosphate application either to soil or as spray, increased the seed yield of cowpea. After many fertilizer trials in the northern parts of Nigeria; Yayock (1975) reported that phosphorus was found to be unquestionably the most important element in cowpea seed production. Research findings at the Institute for Agricultural Research, Samaru-Zaria, Nigeria, have also shown significant yield increases in cowpea due to phosphorus fertilizer application. The fertilizer treatment yielded 24.1% higher than the unfertilized control (Anonymous, 1977).

Phosphorus does not only increase the yields of cowpea, but also improves the quality of the crop. Omueti and Ovenuga (1970), reported that phosphorus fertilization increased the seed protein content of cowpea significantly. Similarly, Kurdikeri, *et al.* (1983) reported an increment of about 5% seed protein content of cowpea as a result of P fertilization. The fodder from phosphorus fertilised cowpea has been reported to form a rich forage material for livestock. Such crops are often found to be rich in many other nutrients such as N, K, Zn, Ca and Mn (Kang and Nangju, 1983).

Phosphorus exerts favourable and positive contributory effects on the yield components of cowpea as evidenced by the significant effects it has on the final yields of the

crop. Singh and Jain, (1966) reported that application of P_2O_5 increased the number of branches, dry weight of shoots and nodules per plant of cowpea. Phosphorus has also been reported to have increased growth, number of leaves per plant, leaf area per plant, number of flowers per plant, number of fruits per plant, as well as earliness of flowering and generally increased yields (Kurdikeri et al. 1977; Tarila et al., 1977). Tarila et al., (1977) further reported that the total number of pods per plant, number of seeds per plant and seed weight per plant were all increased as a result of increasing P contents of the soil. Jarayam and Ramia (1980) observed that P fertilization reduced flower shedding significantly in cowpea. Similarly, Laskar and Dadhwal (1981) reported that as P fertilization was increased, pod abscission was reduced in cowpea in addition to increment in the vegetative and reproductive parts. These results indicate that much of the energy conserved by the crop would result in increased harvestable yields.

It is interesting to note, however, that certain workers have reported some low and neutral effects of phosphorus on the yield components of cowpea. Ezedinma (1965a) reported that though fertilizers significantly increased vegetative growth and yield of cowpea, the yield determinants were not affected. Phosphorus was also observed have no effect on the grain yield and yield components of cowpea in the ———————————————————

growing season of 1983 in a trial at Samaru-Zaria, Nigeria (Anonymous, 1984). Since these workers have not indicated the initial P status of the soils before their studies the negative and neutral results obtained might have been due to the P - saturation of the soils used. This is especially so, since it is known that crop yields usually increase curvilinearly with increasing amounts of the nutrients in which the soil is deficient. An optimum is usually attained which cannot be increased and may even be decreased with additional amounts of the nutrients (Doyle, 1966).

2.2 The Effects of Sources and Levels of Phosphorus on Cowpea

2.2.1 The effects of sources of phosphorus on the growth and yield of cowpea

There are various forms or sources of phosphorus in the soil for plant use. These could be existing naturally in the soil, i.e. the organic and inorganic soil P or added artificially by man through the use of fertilizers. There are various types of phosphatic fertilizers used today. The major ones are: Single superphosphate (SSP, 18% P_2O_5); Triple superphosphate (TSP, 46-47% P_2O_5); Monoammonium phosphate (MAP ,38-39% P_2O_5); Diammonium phosphate (DAP, 48% P_2O_5), Nitrophosphate (20% P_2O_5), and superphosphoric acid (76-85% P_2O_5). Other relatively new products are Magnesium ammonium phosphate (40% P_2O_5); Ammonium poly-

phosphate (40% P_2O_5), Urea phosphate; Monopotassium phosphate; Potassium phosphate; Bulk blends (mixture of ure and conc. superphosphate) Basic slag, Rock phosphate. (Bixby et al., 1984; Allen, 1970; Olson et al., 1971; Anonymous, ISMA, n.d.).

Studies indicate that the efficiency of phosphatic fertilizers is dependent upon the characteristics of the crops, the soil and climatic conditions under which the crop is grown, the chemical and physical propoerties of the fertilizer used and the rate and method of its application (Tisdale and Rucker, 1964; Terman, 1971; Barnes and Kamprath, 1975). The fertilizer properties affecting their efficiencies and crop responses in terms of growth and yields include granule size, fertilizer solubility and formulation (Terman, 1971). Environmental factors influencing phosphorus nutrition of crops include soil characteristics such as pH, texture, temperature, moisture content and the presence of other mineral elements.

Differences in crop growth and yield resulting from the use of different sources of phosphorus have been reported. After many trials using 15 different soils in a pot experiment, Terman (1971), reported that no amount of rock phosphate could produce the yields of Ladino Clover obtained with superphosphate. Iswaran and Altamirano (1975), reported that monoammonium phosphate decreased flower shedding and increased pod weight of cowpea. They observed that monoammonium phosphate was more efficient on the crop

than any other phosphatic fertilizer used. Similarly, Agboola and Obigbesan (1977), reported that seed yield of cowpea with superphosphate and converted bone as sources of P, were singificantly higher than those from rock phosphate and basic slag. They further found that all yield components, pods, seeds and roots followed same pattern as growth. Lombin (1979), also reported that single superphosphate performed significantly better than three other phosphatic fertilizers (ground rock phosphate, calcium metaphosphate and dicalcium phosphate) in the yields of groundnuts and sorghum, in the northern Guinea savanna zone of Nigeria. The effectiveness of the various fertilizers was thought to be a function of their water solubilities.

In contrast, however, some workers (Rhodes, 1980; Pillai et al., 1981), have reported insignificant differences in cowpea yields due to the use of different phosphatic fertilizers . Though it is true that certain phosphatic fertilizers are more efficient than others in boosting the growth and yields of crops, it is worth noting that such efficiency depends greatly on the ability of any given fertilizer to provide high concentration of soluble P within the crop growth medium for rapid early growth to ensure adequate leaf area for photosynthesis which forms the basis for higher yield potentials (Terman, 1971).

2.2.2 The effects of levels of phosphorus on the growth and yield of cowpea

It is fairly well established that certain minimum amount of phosphorus is required for efficient performance in cowpea. In relatively low P-containing soils, several workers have reported tremendous increases in the growth and yields of cowpea with increasing P levels (Yayock, 1975; Kunju et al., 1976; Remison et al., 1980). Several others have also reported various optimal levels of P for attaining maximum growth and yield in cowpea. Garg et al., (1970), after studying the effects of different rates of phosphorus on cowpea, reported that the green fodder yield of the crop was significantly increased by a rate of 37 kg P/ha (85 kg P_2O_5/ha) and not by higher rates. Agboola and Obigbesan (1977), reported that highest grain yield was obtained at 30 kg P/ha (69 kg P_2O_5/ha) from four different phosphatic fertilizers (Rock phosphate, Basic slag, converted bone and superphosphate). In trials conducted at various locations in the savanna ecological zone of Nigeria for many years, it has been found that a rate of 37 kg P_2O_5/ha is optimal for seed yield in cowpea (Anonymous, 1977). It was further observed in 1978 that there were no advantages in applying more than 37 kg P_2O_5/ha for cowpea production in the savanna regions of Nigeria (Anonymous 1979). Okelana and Adedipe,(1981) while working on four levels of P on cowpea in the forest ecological zone of Nigeria however, found that a phosphorus

dress g of 40 kg P/ha (92 kg P_2O_5/ha) proved the nearest optim P level for seed production in New era variety of cowpe . Kang and Nanju (1983), on the other hand, repor ed an optimal level of 13 kg P/ha (30 kg P_2O_5/ha) for c wpea yield in the forest zone of Nigeria.

It is worthy to note, however, that the efficiency of a P level applied to cowpea depends on the properties of t soil, the fertilizer type and crop variety (Terman, 1971 Anonymous, 1977). This may explain the variations in t responses of cowpea to P in the various studies cite . It is, therefore, not surprising that the recommended opti al P rates for cowpea would vary according to agro-clim tes and soil types.

Tavora et al (1971) however, reported that there wer no significant differences in cowpea yields after usi five different P levels, although there were sig ficant differences between the fertilized and unf rtilized crops.

Varietal responses to added P also play an important rol in determining the optimum rate of P for maximum per ormance in cowpea. It was reported in 1977, after num rous trials of P-levels in cowpea that the interaction bet ween varieties and fertilizer levels was highly significant (Anonymous, 1977).

Chapte 3

MATERIALS AND METHODS

3.1 Location

ne experiment was conducted at the Institute for A icultural Research farm at Samaru-Zaria, Nigeria (11°1 N, 07°38'E, 686m above mean sea level), during the 1 6 wet season.

Samaru lies in the Northern Guinea savanna zone of Nige a. It has an average rainfall of about 1,100 mm most distributed between the months of May and October, with mean monthly minimum and maximum temperature of 20 °C and 30 °C, respectively, during this period. Clim tological data collected during the 1986 growing sea are presented in appendix 2. The soil is moderately dee well drained and characteristically tropical sandy loa Analysis of the physical and chemical properties of soil fro the site used for this experiment is presented in app dix 1.

3.2 History of Site

The land was used for tractor-driving instruction are for over 10 years. As such, agronomic experiments re ated to fertilizers have not been carried out on the la d for the past 10 years. Due to proper levelling, the land has efficient drainage layout which prevented it from water logging.

3.3 Treatments and Experimental Design

The treatments consisted of four cowpea varieties (Kano 1696, SV048, 176B and 339-1) (Anonymous, 1985), four levels of phosphate (0, 18.5, 37.0 and 55.5 kg P_2O_5/ha), using two sources of phosphate (Diammonium phosphate 'DAP' and single superphosphate 'SSP'). Urea fertilizer (46% N) was added to the SSP to bring its content of nitrogen equivalent to that in DAP.

The treatments were factorially combined and layed out in a randomized complete block design with three replications. The gross and net plot sizes were 20.25 m^2 and 6.75 m^2, respectively. The gross plot consisted of six ridges of 75 cm width and 450 cm long, while the net plot consisted of the two inner ridges of the gross plot.

3.4 Field Operations

3.4.1 Soil sampling and analysis

Soil samples were collected from randomly selected sites on the field. Samples were taken at two depths (0-15 cm and 15-30 cm) using a tubular auger, prior to cultivation. The soil samples were analysed for physico-chemical properties such as the percent clay, silt and sand, per cent organic carbon, total N, available P, exchangeable bases, cation exchange capacity and soil pH (Appendix 1).

The particle size analysis of the soil was done by hydrometer method, soil pH in H_2O and 0.01M/$CaCl_2$ using a pH meter; organic carbon content by Walkley and Black method; total N by Kjeldahl method; available phosphorus by Bray I method; exchangeable bases by Ammonium acetate saturation and cation exchange capacity by Ammonium acetate extraction and distilation (Black, 1965).

3.4.2 Land preparation

After clearing, the land was ploughed, harrowed twice to obtain a fine tilth and ridged at 75 cm width. The field was marked out into 84 plots of 20.25 m^2 (4.5 m x 4.5 m) each. Paths of 1 m along the rows and 75 cm (one ridge) across the rows were allowed to separate adjacent plots.

3.4.3 Fertilizer application

The two phosphatic fertilizers, DAP (46% P_2O_5) and SSP (18% P_2O_5) were applied pre-planting at the rates of 18.5, 37.0, 55.5 and a control of 0 kg P_2O_5/ha.

3.4.4 Planting and planting materials

The crop was planted on the 15th of July, 1986. Four varieties of cowpea, 1696, SVU48, 176B and 339-1 were used. The 1696 has a spreading growth habit, is late maturing and day-length sensitive. Its seeds are characteristically extra-large in size and white in colour. The SVU48 is a semi-upright variety with brown, medium to

large sized seeds. The 176B is semi-upright, with white medium to large sized seeds while the 339-1 is also semi-upright but with white, medium sized seeds. The last three varieties used are all day-length insensitive (Anonymous, 1985).

Two to three seeds were planted per hole of 4-5 cm depth at 75 cm x 25 cm spacings. The crop was thinned a week after germination, to maintain two plants per stand.

3.4.5 Weed and pest control

'Galex' 50C e.c. (Metolachlor + Metrobromuron) a pre-emergence herbicide was used at 5 l/ha to suppress weed growth. This was applied a day after planting the crop. A supplementary hoe-weeding was done when the crop was 5 weeks old to check weed growth.

To control insect pests, a mixture of cymbush (Cypermethrin) 10 e.c. and Rogor (dimethoate) 40% e.c. was used at the rate of 500 ml + 500 ml in 100 litres of water per hectare and sprayed using the CP-3 knapsack sprayer. Spraying started two weeks after planting when insect infestation of the crop was noted and continued forthnightly up to flowering period. During flowering and podding the crop was sprayed at weekly intervals, using the same mixture of chemicals and at the same rates.

To control fungal infections, Benlate + Dithane M45 were used at the rates of 0.6 kg + 2.5 kg/400 litres of water/ha, starting from four weeks after planting and continued at two weeks interval until crop maturity.

3.4.6 Harvesting

Three of the varieties, SVU 48, 1765 and 339-1 were all harvested at 12 weeks after planting. The variety, 1696 did not flower very well and hence could not produce harvestable yields.

3.5 Observations and Data Collection

3.5.1 Assessment of pre-harvest parameters

Stand count at germination was taken a week after planting the crop. Assessment of parameters such as number of branches per plant, number of leaves per plant, leaf area per plant, plant height and the dry weights of leaves and stems per plant, began at five weeks after planting and continued at two-weeks interval till the 11th week after planting.

Five plants were randomly selected from each plot for sampling. The plants were uprooted and washed carefully before readings were taken. The heights of plants were taken by measuring the stems from the point of emergence from the soil to the highest vertical apex. The number of leaves and branches per plant were taken by simple ccunting, while the leaf area was determined by measuring the areas of the middle leaflets and multiplying by a constant factor of 2.7 or $\frac{1}{0.37}$ as described by Nangju and Wanki (1979)

Observations of characters such as the number of days to first flowering, days to fifty per cent flowering and the number of flowers per plant were also recorded.

3.5.2 Assessment of post-harvest parameters

Parameters assessed after harvest included: number of pods per plant, weight of pods per plants, number of seeds per pod, number of seeds per plant, weight of seeds per plant, weight of 1,000 seeds and the threshing percentage. Crop quality was determined through analysis of per cent crude protein content of grains.

3.5.3 Analysis of data

The analysis of variance of all data collected was done to test for the significant effects of the treatments using the 'F' test as described by Snedecor and Cochran (1967). The multiple comparison procedure of the least significant difference (LSD) was used to compare means of varieties, sources of P and levels of P and their interactions. The Duncan Multiple Range Test (DMRT) (Duncan, 1955) was also used to compare the treatment means. Analysis of correlation coefficients between growth characters, yield components and grain yield of cowpea was also done to determine their relationships.

Chapter 4

RESULTS

4.1 Effect of Sources and Levels of Phosphorus on Growth of Cowpea

4.1.1 Plant height

Height of cowpea plants was significantly influenced by phosphorus levels and cowpea variety, while sources of phosphorus had no significant effect (Table 1).

Plant height increased significantly with increasing levels of phosphorus throughout the sampling period. Although application of P at 55.5 kg P_2O_5/ha produced the tallest plants, they were not significantly taller than those that received 37 kg P_2O_5/ha.

Variety 1696 was generally taller than the others, although the differences between it and other varieties was significant only at 5 and 7 weeks after planting.

The interaction effects of phosphorus sources and cowpea variety significantly influenced plant height at 5 and 7 weeks after planting (Table 2). Variety 1696 was significantly taller than the other varieties irrespective of P source at 5 WAP and when SSP was the P source at 7 WAP. Plants of variety 1696 receiving SSP were significantly taller than those of the same variety receiving DAP at both 5 and 7 WAP.

Table 1 Height of cowpea plants (cm) as influenced by sources and levels of phosphorus at Samaru in 1986

Treatments	Weeks after planting (WAP)			
	5	7	9	11
Sources of P				
Control	12.50b	17.92b	22.08b	24.92b
DAP	19.67a	24.74a	27.86a	31.60a
SSP	21.08a	25.69a	28.13a	30.78a
SED(±)	0.786	00.733	0.969	0.941
Levels of P (P_2O_5 kg/ha)				
0.0	12.50c	17.92c	22.08c	24.92c
18.5	18.73b	22.69b	26.02b	29.23b
37.0	20.83a	26.85a	28.44a	31.75a
55.5	21.56a	26.92a	29.52a	32.58a
SED(±)	0.785	0.898	1.187	1.152
Varieties				
Kano 1696	25.92a	27.58a	28.50a	33.83a
SVU48	18.31b	24.86b	28.39a	32.92a
176B	18.00b	24.42b	27.69a	31.03a
339-1	19.28b	24.00b	27.39a	30.97a
SED(±)	1.111	1.037	1.370	1.331

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

Table 2: Interaction effects (sources of P x cowpea variety) on plant height (cm) at 5 and 7 WAP at Samaru in 1986

	5 weeks after planting (WAP)				7 weeks after planting (WAP			
	Cowpea Varieties				Cowpea Varieties			
Sources of P	Kano	1696	SVU48	176B	339-1	Kano 1696	SVU48	176B	339-1
DAP		23.00b	19.06c	17.17c	19.44c	25.44b	26.00b	23.67b	23.83b
SSP		28.83a	17.56c	18.83c	19.11c	29.72a	29.72b	25.17b	24.17b
SED(±)		1.572				1.466			

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

4.1.2 Number of leaves per plant

Both phosphorus levels and cowpea variety significantly influenced the number of leaves per plant, but the effects of phosphorus sources were not significant (Table 3).

Number of leaves per plant was significantly influenced by phosphorus levels throughout the sampling period, with the number of leaves per plant increasing with increasing levels of phosphorus. The highest number of leaves per plant resulted from the application of 55.5 kg P_2O_5/ha, although this was not significantly different from applying 37.0 kg P_2O_5/ha.

The number of leaves per plant was significantly higher for variety 1696 than the other varieties whose number of leaves per plant were similar.

The interaction effects of sources and levels of P and cowpea variety on the number of leaves per plant were not statistically significant.

4.1.3 Total leaf area (cm^2) per plant

The total leaf area per plant was significantly influenced by sources and levels of phosphorus as well as cowpea variety (Table 4).

Application of SSP as a source of P generally produced higher total leaf area per plant than the use of DAP, and the differences were significant at 7 and 11 weeks after planting.

Table 3 Number of leaves per plant of cowpea as influenced by sources and levels of phosphorus at Samaru in 1986.

Treatments	Weeks after planting (WAP)			
	5	7	9	11
Sources of P				
Control	10.92b	20.90b	36.10b	30.00b
DAP	21.47a	42.10a	55.40a	36.70ab
SSP	20.86a	44.90a	56.80a	43.90a
SED(±)	0.975	2.22	3.63	5.16
Levels of P (P_2O_5kg/ha)				
0.0	19.92c	20.90c	36.10b	30.00b
18.5	18.75b	35.60b	52.90a	34.80ab
37.0	22.17a	45.90a	53.10a	40.50ab
55.5	22.58a	46.50a	62.30a	45.40a
SED(±)	1.194	2.17	4.44	6.32
Varieties				
Kano 1696	24.28a	66.30a	91.90a	69.30a
SVU48	19.78b	40.20b	46.20b	25.60b
176B	19.94b	42.40b	47.90b	38.00b
339-1	20.67b	39.10b	38.40b	28.20b
SED(±)	1.379	3.13	5.13	7.30

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance DMRT.

Table 4 Total leaf area (cm^2) per plant of cowpea as influenced by sources and levels of phosphorus at Samaru in 1986

Treatments	Weeks after planting (WAP			
	5	7	9	11
Sources of P				
Control	607.0b	1183.0c	1988.0b	1765.0b
DAP	1205.0a	2202.0b	3256.0a	2161.0b
SSP	1157.0a	2555.0a	3331.0a	3258.0a
SED(±)	53.3	125.3	210.7	215.9
Levels of P (P_2O_5kg/ha)				
0.0	607.0c	1183.0c	1988.0c	1765.0b
18.5	1045.0b	1999.0b	3095.0b	2059.0b
37.0	1248.0a	2614.0a	3613.0a	2928.0a
55.5	1251.0a	2621.0a	3673.0a	3142.0a
SED(±)	67.7	153.5	258.1	264.4
Varieties				
Kano 1696	1163.0a	3090a	6169.0a	5990.0a
SVU48	1012.0b	2194b	2525.0b	1386.0b
176B	1021.0b	2202b	2488.0b	1980.0b
339-1	1059.0b	2027.b	1992.0b	1482.0b
SED(±)	78.1	77.2	298.0	305.3

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

Total leaf area per plant increased with increasing levels of phosphorus throughout the sampling period. Applying 55.5 kg P_2O_5/ha resulted in the highest total leaf area per plant, though this was s not significantly different from applying 37 kg P_2O_5/ha.

Variety 1696 had significantly higher total leaf area per plant throughout the sampling period, than the other varieties whose differences were not statistically significant.

The interaction effects of sources and levels of phosphorus and cowpea variety on the total leaf area per plant were significant at 11 weeks after planting (Table 5). The total leaf area of 1696 resulting from applying SSP at 37 and 55.5 kg P_2O_5/ha was significantly higher than applying DAP at the same levels.

4.1.4 Leaf dry weight per plant

Both sources and levels of P as well as cowpea variety significantly influenced leaf dry weight per plant (Table 6).

Plants treated with SSP generally produced higher leaf dry weights than those treated with DAP throughout the sampling period, although the differences were significant only at 11 weeks after planting.

Phosphorus levels affected leaf dry weight per plant significantly at 5 and 11 weeks after planting. The leaf dry

Table 5 Interaction effects (sources of P x levels of P x cowpea variety) on leaf area (cm^2) per plant at 11 WAP at Samaru in 1986.

Sources of P	Levels of P (P_2O_5kg/ha)	Cowpea Varieties			
		1596	SVU48	176E	339-1
DAP	0.0	3623bcd	1180def	1130def	1120def
	18.5	4107bc	959ef	1207def	1277def
	37.0	4185b	1604def	1120def	1400def
	55.5	4185b	1143def	2590cdef	1522def
SSP	0.0	3623bcd	1180def	1130def	1120def
	18.5	4890b	737f	2135cdef	1158def
	37.0	9373a	1346def	2887cde	1505def
	55.5	8586a	2525cdef	1942cdef	2030cdef
SED(±)		747.9			

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT

Table 6 Leaf dry weight (g) per plant of cowpea as influenced by sources and levels of phosphorus at Samaru in 1986

Treatments	Weeks after planting (WAP)			
	5	7	9	11
Sources of P				
Control	1.63b	6.27b	11.58b	8.29b
DAP	4.22a	11.23a	14.43a	9.65b
SSP	4.29a	11.23a	15.29a	12.85a
SED(±)	0.320	0.917	1.064	1.455
Levels of P (P_2O_5kg/ha)				
0.0	1.63c	6.27b	11.58b	8.29b
18.5	3.42b	10.59a	14.29a	9.71b
37.0	4.42a	11.03a	14.40a	13.15a
55.5	4.49a	12.07a	15.90a	13.90a
SED(±)	0.392	1.123	1.303	1.782
Varieties				
Kano 1696	4.33a	11.94a	19.08a	17.00a
SVU48	4.42a	11.04a	14.86b	12.42b
176B	4.08a	11.86a	14.64b	12.44b
339-1	4.19a	10.48a	10.86c	12.33c
SED(±)	1.53	1.297	1.505	2.058

Means followed by the same letter(s) within a treatment are not statistically different at 5% level of significance using DMRT.

weight increased significantly with increasing levels of P. Although applying 55.5 kg P_2O_5/ha produced the highest leaf dry weight per plant, it was not significantly higher than the weight obtained from applying 37 kg P_2O_5/ha. At 7 and 9 weeks after planting, although the fertilized treatments produced significantly higher weights than the unfertilized control, the differences between three fertilized treatments were not significant.

Varietal differences in leaf dry weight per plant were significant only at 9 and 11 weeks after planting. At 9 weeks after planting, leaf dry weight of 1696 was significantly higher than those of SVU 48 and 176B, which were, in turn significantly higher than that of 339-1.

There were no significant interaction effects of sources and levels of P and cowpea variety on leaf dry weight per plant throughout the sampling period.

4.1.5 Stem dry weight per plant

The different sources and levels of phosphorus and cowpea variety did not influence stem dry weight per plant significantly throughout the sampling period, although the fertilizer treatments were significantly higher in stem dry weight per plant than the control treatments (Table 7). Stem dry weight per plant were similar for all the varieties used, although 176B tended to have higher stem dry weights than the other varieties at 7, 9 and 11 weeks after planting.

Table 7 Stem dry weight (g) per plant of cowpea as influenced by levels and sources of phosphorus at Samaru in 1986.

Treatments	Weeks after planting (WAP)			
	5	7	9	11
Sources of P				
Control	0.683b	4.30b	10.70b	15.25b
DAP	2.194a	10.70a	23.30a	25.93a
SSP	2.106a	13.20a	23.20a	26.52a
SED(±)	1.676	2.98	2.90	1.872
Levels of P (P_2O_5kg/ha)				
0.0	0.683b	4.30b	10.70b	15.25b
18.5	2.287a	9.20a	21.40a	24.06a
37.0	2.304a	15.30a	26.40a	26.25a
55.5	2.458a	11.40a	26.37a	28.37a
SED(±)	0.205	3.56	3.55	2.293
Varieties				
Kano 1696	2.556b	10.70a	20.80a	24.78a
SVU48	1.917a	12.60a	23.10a	24.47a
176B	2.056a	15.40a	30.20a	30.83a
339-1	2.072a	9.20a	22.80a	24.83a
SED(±)	0.237	4.22	4.10	2.648

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

The interaction effects of sources and levels of P and cowpea variety on stem dry weight per plant were not significant throughout the sampling period.

4.1.6 Shoot dry weight per plant

Shoot dry weight per plant was significantly influenced by phosphorus levels and cowpea variety, but not by sources of phosphorus (Table 8).

Shoot dry weight per plant increased significantly with increasing levels of phosphorus at 5 and 11 weeks after planting. Applying 55.5 kg P_2O_5/ha resulted in the highest shoot dry weight per plant, though not significantly higher than applying 37 kg P_2O_5/ha. At 7 and 9 weeks after planting, though the fertilized treatments had significantly higher shoot dry weights per plant than the unfertilized control, the differences between the three fertilized treatments were not significant.

Varietal differences in shoot dry weight per plant were significant only at 9 and 11 weeks after planting. Varieties 1696, SVU48 and 176B were all statistically similar in their shoot dry weights per plant, but significantly higher than variety 339-1 which had the least shoot dry per plant.

The interaction effects of sources and levels of P and cowpea variety on shoot dry weight per plant were not significant throughout the sampling period.

Table 8 Shoot dry weight (g) per plant of cowpea as influenced by sources and levels of phosphorus at Samaru in 1986.

Treatments	Weeks after planting (WAP)			
	5	7	9	11
Sources of P				
Control	2.51b	9.56b	24.70b	25.30b
DAP	6.47a	22.03a	39.30a	34.70a
SSP	6.41a	21.95a	42.30a	39.10a
SED(±)	0.465	1.545	2.99	3.00
Levels of P (P_2O_5kg/ha)				
0.0	2.51c	9.56b	24.70b	25.30c
18.5	5.29b	19.99a	36.70a	32.90b
37.0	6.68ab	21.63a	40.30a	41.70a
55.5	7.35a	24.35a	45.50a	43.10a
SED(±)	0.569	1.892	3.66	3.68
Varieties				
Kano 1696	6.89a	20.45a	42.20a	44.00a
SVU48	6.31a	25.19a	44.80a	42.90a
176B	6.14a	21.97a	42.60a	42.80a
339.1	6.43a	20.36a	33.60b	29.90b
SED(±)	0.657	2.184	4.22	

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

4.2 Effects of Sources and Levels of Phosphorus on the Yield and Yield Components of Cowpea

Variety 1696 failed to produce harvestable yields, therefore, yield data were recorded for only three varieties viz: SVU48, 176B and 339-1.

4.2.1 Grain yield (kg/ha)

Grain yield was significantly influenced by phosphorus levels and cowpea variety, but not by sources of phosphorus (Table 9a).

Yield increased significantly with increasing levels of phosphorus. Although applying 55.5 kg P_2O_5/ha resulted in the highest grain yield of cowpea, (2784kg/ha), this was not significantly different from the grain yield obtained from applying 37 kg P_2O_5/ha, which yielded 2585kg/ha .

The yield of variety SVU48 (3043kg/ha), was significantly higher than those of 176B and 339-1 whose grain yields were similar (1770kg/ha and 1894 kg/ha respectively).

The interaction effects of phosphorus level and cowpea variety significantly influenced grain yield of cowpea (Table 9b). All the three varieties yielded highest when phosphorus was applied at 55.5 kg P_2O_5/ha, but the increases due to the last increment in P rate were minor for varieties SVU 48 and 176B (4.0% and 0.2% respectively) compared to that of variety 339-1 (22.1%).

Table 9a Effects of sources of P and levels of P on cowpea variety on grain yield (kg/ha) of cowpea at Samaru in 1986.

	Sources of P			
	Control	DAP	SSP	SED(±)
Grain yield kg/ha)	1391b	2114a	2319a	106.7

	Levels of P (P_2O_5 kg/ha)				
	0.0	18.5	37.0	55.5	SED (±)
Grain yield (kg/ha)	1391b	2182b	2585a	2784a	130.6

	Varieties				
	SVU48	176B	339-1	Kano 1696	SED(±)
	3043a	1770b	1894b	-	130.6

Table 9b Interaction effects (levels of P x cowpea variety) on grain yield (kg/ha) of cowpea at Samaru in 1986.

Levels of P (P_2O_5 kg/ha)	Grain Yield (kg/ha) Cowpea Varieties			
	SVU48	176B	339-1	Kano 1696
0.0	2051de	903f	1218ef	-
18.5	2928b	1660d	1957d	-
37.0	3538a	2259bc	1962bcd	-
55.5	3653a	2260bc	2438bc	-
SED(±)	226.3			

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

Table 10 Effects of sources and levels of phosphorus on threshing percentage and percent crude protein of cowpea varieties at Samaru in 1986

Treatments	Threshing percentage	Precent Crude protein
Sources of P		
Control	67.10a	22.03a
DAP	69.60a	22.01a
SSP(	73.00a	22.21a
SED(±)	3.62	0.315
Levels of P (P_2O_5 kg/ha)		
0.0	67.10a	22.03a
18.5	70.50a	22.22a
37.0	74.70a	22.12a
55.5	68.60a	21.99a
SED(±)	4.44	0.386
Varieties		
SVU48	76.30a	21.02b
176B	70.20a	23.00a
339-1	67.40a	22.31a
Kano 1696	-	-
SED (±)	4.44	0.386

Means followed by the same letters within a treatment are not signficiantly different at 5% level of significance using D.M.R.T.

4.2.2 Threshing percentage

Threshing percentage of cowpea was not significantly influenced by sources and levels of phosphorus or cowpea variety (Table 10). Similarly, none of the interaction effects of sources and levels of phosphorus and cowpea variety on theshing percentage was significant.

4.2.3 Percent crude protein

Phosphorus sources and levels did not influence the crude protein content of cowpea significantly. There were however, significant differences in crude protein contents of the different cowpea varieties (Table 10).

The variety 176B had the highest crude protein content, and this was significantly higher than that of SVU48 which had the least crude protein content, but the difference between 176B and 339-1 was not significant.

There were no significant interaction effects of sources and levels of phosphorus and cowpea variety on the crude protein content.

4.2.4 Number of days to first flowering

The different sources and levels of phosphorus did not affect the number of days to first flowering significantly, although there were significant differences between the fertilizer treatments and the control. There were however significant varietal differences in the number of days to first flowering (Table 11).

SVU 48 flowered earliest at about 41 days after planting, followed by 339-1 at about 44 days after planting, while variety 176B flowered latest at almost 47 days after planting.

There were significant interaction effects of phosphorus sources and cowpea variety (Table 12). Applying DAP increased the average number of days to first flowering by 0.22 days in both varieties SVU 48 and 339-1 and by 0.78 days in variety 176B as compared to SSP.

4.2.5 Number of days to 50% flowering

Both sources and levels of P had no significant effect on the number of days to 50% flowering, but there were significant varietal differences (Table 11).

As with the number of days to first flowering, the number of days to 50% flowering was significantly earlier for SVU 48, followed by 339-1, while 176 B took the longest number of days to produce 50% of its flowers.

The interaction effects of phosphorus sources and cowpea variety significantly influenced the number of days to 50% flowering (Table 12). The source of P had no significant effect on the number of days to 50% flowering in varieties SVU 48 and 176B but plants of variety 339-1 that received SSP attained 50% flowering significantly earlier (by 3 days) than those that received DAP.

Table 11: Effects of sources and levels of phosphorus on number of days to first flowering, number of days to 50% flowering and number of flowers per plant of cowpea at Samaru in 1986.

Treatments	No. of days to flowering	No. of days to 50% flowering	No. of flowers per plant
Sources of P			
Control	49.56a	53.67a	32.20b
DAP	46.49b	52.92a	52.10a
SSP	46.93b	52.42a	53.50a
SED(±)	0.394	0.462	3.67
Levels of P (P_2O_5kg/ha)			
0.0	49.56a	53.67a	37.20c
18.5	47.78b	52.75a	50.70a
37.0	47.00b	52.33a	58.30a
55.5	47.89b	52.92a	59.50a
SED(±)	0.432	0.566	4.50
Varieties			
SVU48	41.22c	44.1c	69.60a
176B	46.61a	50.72a	48.10b
339-1	43.78b	47.83b	50.60b
Kano 1696	-	-	-
SED (±)	0.65	0.483	4.50

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

Table 12 Interaction effects (sources of P x cowpea variety) on the number of days to first flowering, number of days to 50% flowering, and number of flowers per plant at Samaru in 1986.

	No. of days to first flowering				No. of days to 50% flowering				No. of flowers per plant			
	Cowpea Varieties				Cowpea Varieties				Cowpea Varieties			
Sources of P	SVU48	176B	339-1	Kano 1696	SVU48	176B	339-1	Kano 1696	SVU48	176B	339-1	Kano 1696
DAP	41.33c	47.00a	44.89b	-	44.56d	50.87a	49.33b	-	51.3bc	46.7bc	58.3ab	-
SSP	41.11c	46.22ab	44.67b	-	43.67d	50.78a	46.33c	-	67.8a	49.4bc	43.3bc	-
SED(±)		0.92				0.683				6.36		

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

4.2.6 Number of flowers per plant

Levels of phosphorus and cowpea variety significantly influenced the number of flowers per plant, but the effects of phosphorus sources were not significant (Table 11).

The number of flowers per plant increased with increasing levels of P. Applying 55.5 kg P_2O_5/ha resulted in the highest number of flowers per plant, although this was not significantly higher than applying 37 kg P_2O_5/ha.

The number of flowers per plant was significantly higher for variety SVU48 than the other varieties whose difference was not significant.

The interaction effects of phosphorus sources and cowpea variety significantly affected the number of flowers per plant of cowpea (Table 12). Applying SSP resulted in a higher number of flowers per plant for varieties SVU48 and 176B, while for 339-1 applying DAP resulted in more flowers per plant than when SSP was the P source.

4.2.7 Number of pods per plant

The number of pods per plant was significantly influenced by phosphorus levels and cowpea variety, but not by sources of phosphorus (Table 13).

Increasing levels of P increased the number of pods per plant significantly. The highest number of pods per plant was obtained from applying 55.5 kg P_2O_5/ha, though this was not significantly higher than applying 37 kg P_2O_5/ha.

Table 13 Effects of sources and levels of phosphorus on on some yield components of cowpea at Samaru in 1986.

Treatments	No.of pods/ plant	No. of seeds/ plant	Wt of pods(g)/ plant	Wt of seeds(g)/ plant	1000 seeds weight(g)
Sources of P					
Control	24.90b	236.0b	35.50b	27.10b	122.80a
DAP	46.00a	430.0a	61.20a	47.70a	126.80a
SSP	48.30a	468.0a	71.00a	50.40a	135.70a
SED(±)	3.84	40.20	6.41	4.33	6.48
Levels of P (P_2O_5kg/ha)					
0.0	24.90c	236.0c	35.50c	27.10c	122.80a
18.5	42.60b	394.0b	58.90b	46.60b	129.40a
37.0	54.00a	498.0a	68.50a	52.40a	135,50a
55.5	53.80a	560.0a	80.90a	60.20a	128.80a
SED(±)	4.71	49.20	7.85	5.30	7.94
Varieties					
SVU48	54.30a	512.0a	79.50a	57.50a	136.00a
176B	42.40b	420.0a	58.00b	43.30b	130.10a
339-1	44.70b	414.0a	60.70b	46.40b	127.60a
Kano 1696	-	-	-	-	-
SED(±)	4.71	49.20	7.85	5.30	7.94

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using D.M.R.T.

The number of pods per plant was significantly higher for variety SVU 48 than the other varieties whose difference was not significant.

The interaction of phosphorus sources and cowpea variety significantly influenced the number of pods per plant (Table 14). Applying SSP resulted in higher number of pods per plant for varieties SVU48 and 176B than the use of DAP though the difference was significant only in SVU 48. The use of DAP however resulted in higher number of pods per plant than SSP for variety 339-1, but the difference between the two sources was not significant.

4.2.8 Number of seeds per plant

The number of seeds per plant was significantly affected by levels of P but not by P sources and cowpea variety (Table 13).

Increasing P levels increased the number of seeds per plant significantly. The highest number of seeds per plant was obtained from applying 55.5 kg P_2O_5/ha, though this was not significantly different from the number of seeds per plant obtained by using 37 kg P_2O_5/ha.

The interaction effects of P sources and cowpea variety significantly affected the number of seeds per plant of cowpea (Table 13). The number of seeds per plants of SVU 48 was significantly higher when SSP was the P source than with DAP. In the two other varieties, P sources had no significant effect on the number of seeds per plant.

Table 14: Interaction effects (sources of P x cowpea variety) on the the number of pods per plant, number of seeds per plant and weight of pods(g) per plant at Samaru in 1986

	Number of pods per plant Cowpea Varieties				Number of seeds per plant Cowpea Varieties				Weight of pods(g) per plant Cowpea Varieties			
Sources of P	SVU48	176B	339-1	Kano 1696	SVU48	176B	339-1	Kano 1696	SVU48	176B	339-1	Kano 1696
DAP	45.6b	40.9b	51.6ab	-	416b	416b	456b	-	64.2b	52.3b	67.1b	-
SSP	63.0a	44.0b	37.8b	-	508a	425b	371b	-	94.9a	63.7b	54.4b	-
SED(±)	6.66				69.60				11.11			

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

4.2.9 Weight of pods per plant

Weight of pods per plant was significantly affected by P levels and cowpea variety, but not by sources of P (Table 13).

Pod weight per plant increased significantly with increasing levels of P. The highest weight resulted from the application of 55.5 kg P_2O_5/ha, though this was not significantly different from the application of 37 kg P_2O_5/ha.

Weight of pods per plant was significantly higher for SVU 48 than for 176B or 339-1. The difference in pod weight between the two latter varieties was not significant.

The interaction effects of P sources and cowpea variety significantly affected the weight of pods per plant of cowpea (Table 14). With SSP as the P source, the pod weight per plant of SVU48 was significantly higher than those of the other varieties, whose differences were similar as a result of applying SSP. There were however no significant varietal differences in pod weight per plant when DAP was used as the P source.

4.2.10 Weight of seeds per plant

Levels of P and cowpea variety significantly influenced the weight of seeds per plant, while P sources had no significant effect (Table 13).

Seed weight per plant significantly increased with increasing levels of P. Although application of 55.5 kg P_2O_5/ha resulted in the highest seed weight per plant, this was not significantly higher than when 37kg P_2O_5/ha was applied.

The seed weight per plant of SVU48 was significantly higher than those of 176B and 339-1 whose seed weights were statistically similar.

The interaction effects of sources and levels of P and cowpea variety on seed weight per plant were not significa statistically.

4.2.11 1000-seed weight

All treatments (i.e. sources and levels of P and cowpea variety), had no significant effect on 1000-seed weight of cowpea (Table 13).

Similarly the interaction effects of P sources and levels and cowpea variety did not affect 1000-seed weight significantly.

4.3 Correlation Analysis

Analysis of correlation coefficients between different growth characters, yield components and yield of cowpea was done to determine their relationships (Table 15).

Table 15 Matrix of coefficient of correlation (r) between grain yield, yield component and growth of three cowpea varieties (SVU48, 176B and 339-1)

	Grain yield	No.of flowers /plant	No.of days to 50% flowering	%Crude Protein	1000 seed wt.	No.of seed/ plant	No.of pods/ plant	Leaf area at 7WAP	No.of leaves /plant at 7WAP	Plant height at 7WAP
Grain yield (kg/ha)	1.00									
No. of flowers/plant	0.44**									
No.of days to 50% flowering	-0.68**	-0.49**								
% Crude protein	-0.35**	-0.14	0.40**							
1000 seed weight(wt)	0.29*	0.20	-0.22	0.13						
No. of seeds/plant	0.42**	0.85**	-0.41**	-0.14	0.16					
No. of pods/plant	0.48**	0.98**	-0.52**	-0.15	0.19	0.87**				
Leaf area/plant at 7 WAP	0.35**	0.26*	-0.21	0.11	0.20	0.27	0.32			
No. of leaves/plant at 7WAP	0.30*	0.23	-0.15	0.15	0.19	0.25*	0.30	0.99**		
Plant height 7 WAP	0.25*	0.20	-0.23	0.06	0.03	0.31*	0.28*	0.42**	0.42*	1.00

NB: * Significant at 5% level of significance
** Significant at 1% level of significance

There were significant positive correlation between yield and leaf area per plant, number of leaves per plant, plant height (all at 7 WAP); number of flowers per plant, number of seeds per plant and 1000-seed weight of cowpea. Significantly negative correlations were observed between yield and number of days to 50% flowering and percent crude protein.

There were significant positive correlations between the leaf area per plant, number of leaves per plant, plant height (at 7 WAP) and the number of pods and seeds per plant of cowpea. There was also significant positive correlation between cowpea plant height and and the number of leaves and leaf area per plant.

The number of flowers per plant, number of pods per plant and the number of seeds per plant were significantly and positively correlated with each other. The number of days to 50% flowering was however significantly and negatively correlated with the number of pods and seed per plant of cowpea.

Chapter 5

DISCUSSION

5.1 Effect of Sources of Phosphorus

Cowpea plants treated with SSP had significantly higher total leaf area and leaf dry weight per plant than those treated with DAP. Other growth parameters such as plant height, number of leaves and shoot dry weight per plant, though insignificantly different, were generally higher due to the use of SSP than DAP. Furthermore, plants receiving SSP as P-source retained their leaves longer as evidenced by differences in number of leaves per plant, total leaf area per plant and leaf dry weight per plant between the 9th and 11th weeks after planting. Use of DAP as a P-source caused decreases in the order of 33.8%, 33.6% and 33.1% respectively in number of leaves per plant, total leaf area perplant and leaf dry weight per plant between the 9th and 11th weeks after planting. Comparable figures when SSP was used as the P-source were 22.7%, 2.2% and 16.0% respectively for number of leaves, total leaf area and the leaf dry weight per plant (Tables 3, 4 and 6). The results thus indicate that SSP was more effective than DAP on the vegetative development and leaf area duration of cowpea. This will suggest that more photosynthetic area was available for carbon assimilation in terms of both space and time when SSP was used as the P-source than when DAP was applied.

These observations are similar with the findings of Terman (1971), Agboola and Obighesan (1977) and Lombin (1979) in which SSP was reported to have performed significantly better than other phosphatic fertilizers (rock phosphate, basic slag, calcium metaphosphate, dicalcium phosphate) on cowpea, groundnuts, ladino clover and sorghum. The superiority of SSP over DAP in the vegetative growth of cowpea in this study could be due to its higher ability to provide high concentration of soluble P within the crop's growth medium for rapid early growth which promoted high total leaf area of the crop. To support this possibility, Terman (1971) and Lombin (1979) are of the view that the effectiveness of various phosphatic fertilizers could be a function of their various solubilities. Thus, SPP being relatively more soluble than DAP (Tisdale and Rucker 1964) was able to effect higher vegetative growth in cowpea.

Cowpea yield and yield components were also generally higher by 5 to 14% as a result of applying SSP than DAP, though the differences were not significant. The results are similar to those obtained by Rhodes (1980) and Pillai et al. (1981) in which the use of different phosphatic fertilizers (single superphosphate and basic slag) resulted in no significant differences in cowpea yields.

Any environmental condition that promotes the availability of P from different phosphatic fertilizer such that adequate amounts required by the cropare supplied within the growth medium, may cause insignificant yield differences. The moisture contents of a soil has been established as an important environmental factor affecting crop response to different phosphates (Tisdale and Rucker, 1964). There was adequate soil moisture during the reproductive growth stages of cowpea during this experiment, it is, therefore, not surprising that the crop yields due to the use of SSP and DAP were not significantly different.

5.2 Effect of Levels of Phosphorus

Plant height, number of leaves, leaf area, leaf dry weight and shoot dry weight per plant, all increased with increasing levels of phosphorus. Plant treated with phosphorus were generally more robust in growth and produced significantly higher vegetative growth characters than those in the control. This observation is similar to the reports of Kurdikeri et al. (1973); Garg et al. (1980), in which phosphor was reported to have caused the robust growth and development of cowpea and generally increased the crop yields. The general improvement of vegetative growth characters of

cowpea by phosphorus levels was no doubt due to its ability to promote crop growth and development by affecting efficient root growth and development and consequently enhanced nutrient uptake for vigorous vegetative growth. (Brady, 1952; Ezedinma 1965; Singh and Jain, 1966; Black 1968; Hari et al., 1978; Negi et al., 1982).

Growth parameters such as plant height, number of leaves, leaf area, leaf dry weight and shoot dry weight per plant were generally highest in plants treated with 55.5 kg P_2O_5/ha though not significantly higher than those treated with 37 kg P_2O_5/ha. This may be due to the fact that application of P up to a level of 37 kg P_2O_5/ha might have been up to the optimal P requirement of the crop. Thus, further additions of P from 37 to 55.5 kg P_2O_5/ha had no significant effects on the crop's growth and development. The results are in agreement with the observations at Samaru (Anonymous, 1979) in which no growth advantages were found in applying more than 37 kg P_2O_5/ha in cowpea.

Application of phosphorus enhanced earliness of flowering in cowpea. Plants that received fertilizers generally flowered by 3 to 5 days earlier than the non-fertilized control. This is in conformity with the findings of Tarila et al. (1977); Narayam and Ramiah (1980) who reported that P fertilization increased earliness of flowering and reduced flower shedding in cowpea. Adequate supply of

phosphorus to plants has been found to encourage earlier crop maturity through efficient flowering with consequent increases in yields (Brady, 1952; Black 1968).

The grain yield and yield components of cowpea were significantly influenced by phosphorus levels. The total grain yield, number of pods, number of seeds, pod weight and seed weight per plant all increased with increasing level of phosphorus. Tarila et al. (1977) obtained similar results with increasing levels of phosphorus in the yield and yield components of cowpea. These results are also in conformity with the established fact that phosphorus is the most important nutrient element affecting the grain yield of cowpea (Gills et al., 1971; Kurdikeri et al., 1973; Kayock 1975; Anonymous, 1977).

The grain yield and all the yield components of cowpea were generally highest due to the application of 55.5 kg P_2O_5/ha, though not significantly higher than the application of 37 kg P_2O_5/ha. Applying 37 kg P_2O_5/ha increased cowpea yield and yield components by 36 to 54 % over the control, while applying P from 37 to 55.5 kg P_2O_5/ha resulted in only 0.35 to 15% increments which were however insignificant statistically. The lack of yield advantages in increasing P application from 37 to 55.5 kg P_2O_5/ (2784 to 2585 kg/ha) may be due to the fact that application of P at 37 kg P_2O_5/ha might have been adequate enough for optimum cowpea yields. Thus, raising the level of P from 37 to 55.5 kg P_2O_5/ha resulted in no

significant yield advantage in the crop. This is in conformity with the results obtained from trials conducted at different locations in the Savanna ecological zone of Nigeria (Anonymous, 1977; 1979) in which an optimal P-level of 37 kg P_2O_5/ha was reported for grain yield in cowpea, and no added advantages were found in applying P above this level. It also agrees with the current recommended P-level for optimum cowpea yields in the Nigerian savannas (Anonymous, 1985). Yusuf (1987) also obtained similar results at Samaru and reported that highest yields and yield components of cowpea resulted from the application of 40 kg P_2O_5/ha than the application of 80 kg P_2O_5/ha. Several other workers (Garg et al., 1970; Agboola and Obigbesan, 1977; Okelana and Adedipe, 1981; Kang and Nangju, 1983), have earlier reported various optimal P-levels on cowpea in different agroclimates and soil types which resulted in optimum yields without any yield advantages from applying P above such levels.

The yield of any agricultural crop is dependent on the efficiency and size of its photosynthetic system (Loomis and Williams, 1963). This is determined during the vegetative growth of the crop. Phosphorus apart from it significant role in the growth of crops also plays a key role in the photosynthetic system of the crop. It is important in the photophosphorylation of various intermediates in the carbon dioxide assimilation process and in the formation of

pyrophosphate bonds which allows energy transfer in plants (Mengel and Kirkby, 1979). It is, therefore, expected that adequate supply of phosphorus will result in good crop growth and consequent high yields in cowpea. Similar results of high yields have been obtained from cowpea which had efficient growth development as a result of adequate supply of phosphorus (Tarila et al.1977; Remison et al., 1980).

5.3 · Effect of Variety

Plant height, leaf area, leaf dry weight, number of days to flowering, total grain yield, number of pods, weight of pods and seeds per plant were all significantly influenced by cowpea variety. 1696 was generally more vigorous in growth than the other varieties whose growth characters were statistically similar. This is not surprising since these characteristics are genetically controlled, although they are also influenced by environmental factors (Anoymous, 1985).

Although the three varieties (SVU 48, 176B, 339-1) harvested had similar vegetative growth, SVU 48 out-yielded 176B and 339-1 by 48% and 38% respectively. The yield components of the varieties also followed similar trends. Variety SVU48 produced 31% and 27% more flowers per plant, 21% and 18% more pods per plant, 16% and 19% more seeds per plant, 27% and 24% greater pod weight per plant and 25% and 19% greater seed weight per plant than varieties 176B and 339-1,

respectively. Similar results were reported by Yusuf (1987), in which SVU 48 yielded higher than two other cowpea varieties (Ife Brown and 176B). This high yielding ability of SVU48 might be due to the fact that the variety has a higher yield potential (Leleji, 1983) and a higher response to phosphatic fertilizers than the other varieties. The fertilizer efficiency on crop yield, is known to be dependent on crop variety, among other factors (Terman, 1971; Anonymous, 1977).

5.4 Effect of Interactions

The interaction effect of P-levels and cowpea variety significantly influenced grain yield. The effect on the yield of SVU48 was significantly higher than the other varieties at equivalent fertilizer levels. This shows that SVU has a higher response to fertilizer, and that application of adequate fertilizer can boost its yields. The results are similar to the findings at Samaru (Anonymous, 1977) in which a highly significant interaction effect between cowpea variety and P-levels was reported after numerous trials.

The interaction effects of P-sources and cowpea variety significantly influenced earliness to flower, number of flowers, number of pods, number of seeds and weight of pods per plant of cowpea. SVU48 flowered 6 to 7 days and 4 to 5 days earlier than 176b and 339-1, respectively, as a result of applying either phosphatic fertilizers although applying SSP affected earlier flowering in SVU 48 by a day

earlier than DAP. Also applying SSP to SVU48 increased its number of flowers per plant by 24.34% number of pods per plant by 27.62%, number of seeds per plant by 31.60% and pod weight per plant by 32.4% than applying DAP. This might have been so because SVU48 exhibited a higher affinity for phosphatic fertilizers, thus, a fertilizer which will easily supply P within the soil solution for crop use will boost the yields of this variety. Since SSP has a higher solubility than DAP (Tisdale and Rucker, 1964), P will be more readily available from SSP than DAP for crop use. SVU 48 which appeared to have had a higher response to P-fertilizers might have been able to utilise the available P more efficiently than the other varieties hence it yielded higher from SSP than DAP. These results are in conformity with the views of Terman (1971), that the efficiency of any phosphatic fertilizer is affected by the type of fertilizer and crop variety used.

5.5 Correlation

The significant positive correlations observed between cowpea yield and growth characters such as number of leaves, leaf area and plant height may be attributed to the fact that these vegetative characters directly determined the amount of photosynthates available for plant growth and grain development. Vigorous vegetative growth enhanced efficient photosynthetic activities of the crop. The resulting photosynthates are thus translocated to the

storage sinks for grain development. Plant height was significantly and positively correlated to yield probably because increased height exposed the plants to greater light for photosynthesis. This was further confirmed by the highly significant and positive correlation of plant height to leaf area and number, all of which are important determinants of photosynthate accumulation and hence crop yields. A highly significant and positive correlation between plant height and grain yield of cowpea have been reported (Singh et al., 1982).

The highly significant and positive correlation between number of flowers, number of pods, number of seeds per plant and 1000-seed weight with grain yield revealed these as important yield components and critical determinants of cowpea grain yield. The results are similar to the findings of previous workers (Aryeetey and Laing, 1973; Chauhuan and Joshi, 1980; Oliveira et al., 1982; Singh et al., 1982), in which the number of seeds per plant and 1000-seed weight were found to be important yield components of cowpea.

Chapter 6

SUMMARY AND CONCLUSION

A field experiment was conducted at the Institute for Agricultural Research farm at Samaru during the 1986 wet season, to investigate the effect of sources and levels of phosphorus on the growth and yield of cowpea (Vigna unguiculata (L) Walp.) varieties.

The treatments consisted of four cowpea varieties (1696, SVU48, 176B, 339-1); four P-levels (0, 18.5, 37.0, 55.5 kg P_2O_5/ha and two P-sources (Diammonium phosphate 'DAP', single superphosphate 'SSP'). These were factorially combined and laid out in a randomized complete block design with three replications.

Application of SSP resulted in significantly higher leaf area and leaf dry weight per plant than the application of DAP. Plant height, number of leaves and shoot dry weight per plant, grain yield and yield components were also higher due to the use of SSP than DAP though the differences were insignificant.

Cowpea growth characters, yield and yield components increased significantly with increasing levels of phosphorus. Application of 37 kg P_2O_5/ha gave a 54% increase in yield over the control. There was no significant growth or yield advantages in increasing P-level from 37 to 55.5 kg P_2O_5/ha.

Varietal effect on the growth and yield of cowpea were highly significant. Variety Kano 1696 was more vigorous in growth than the other varieties although it failed to produce harvestable yields. SVU48 yielded higher than 176B and 339-1 by 48% and 38%, respectively.

The interaction effect of P-levels and cowpea variety significantly influenced grain yield. SVU 48 gave greater responses in yield to successive increases in P-levels than 176B and 339-1. The interaction effects of sources of P and cowpea variety significantly influenced crop earliness to flowering, number of flowers, pods, seeds and pod weight per plant of the crop. Applying SSP to SVU48 resulted in earlier flowering and higher yield components than applying DAP.

The correlation between grain yield, yield components (number of flowers, pods, seeds per plant and 1000-seed weight) and vegetative growth characters (plant height, number of leaves and leaf area per plant) were highly significant and positive.

Based on these findings, it can be concluded that the application of either SSP or DAP at 37 kg P_2O_5/ha under adequate soil moisture conditions, would ensure high yields from cowpea. SVU48 is a high yielding variety and does not require more than 37 kg P_2O_5/ha for optimum yields irrespective of P-sources although the use of SSP may be preferred to DAP on this variety. In the subsistence mixed farming systems of the Nigerian savannas, where farmers are interest in attaining high cowpea yields as well as feeding the forage to livestock, the use of SSP may be preferred to DAP on cowpea.

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Appendix 1 Physico-chemical properties of soil of the experimental site at Samaru, Zaria.

Soil Characteristics	Soil Depth in cm	
	0-15	15-30
Percent clay	9.6	18.0
Percent silt	27.6	26.4
Percent sand	62.8	55.6
Textural class	Sandy loam	Loam
pH in H_2O	5.3	5.4
pH in 0.01M $CaCl_2$	4.9	5.0
Organic carbon (%)	0.324	0.292
Total nitrogen (%)	0.256	0.264
Available phosphorus (ppm)	1.63	0.98
C.E.C. (meq/100g soil)	5.44	7.04
Exchangeable Bases (meq/100g soil)		
Ca	2.84	2.85
Mg	0.88	0.88
K	0.18	0.19
Na	0.05	0.05

Appendix 2 Total rainfall, mean temperature, relative humidity and sunshine hours at ten-day intervals during the period of the trial at Samaru in 1986

Month	Days	Total rainfall (mm)	Mean Temperature (°C) max.	min.	Relative Humidity (%) A.M.	P.M.	Sunshine (hours)
May	1-10	11.2	30.1	20.4	57	31.7	8.0
	11-20	18.4	27.7	21.7	62.9	42.2	7.0
	21-31	29.5	28.6	20.2	55	38.3	8.0
June	1-10	35.3	29.8	20.0	75.6	64.1	7.0
	11-20	22.6	30.2	20.6	74.3	55.8	9.1
	21-30	24.1	30.0	20.1	75.3	59.0	7.4
July	1-10	52.9	29.0	20.0	79.8	62.1	7.0
	11-20	49.4	27.8	19.5	83.4	66.0	7.1
	21-31	65.0	27.0	19.6	83.1	73.1	5.2
August	1-10	50.6	28.1	19.3	83.0	76.9	5.8
	11-20	94.9	28.5	19.7	84.3	66.0	7.1
	21-31	77	29.1	19.4	78.3	70.5	7.7
September	1-10	56.4	28.0	19.5	77.5	68.9	7.1
	11-20	81.2	29.3	18.6	72.6	64.2	8.6
	21-30	75.3	29.3	19.1	76.4	69.2	7.8
October	1-10	0.0	30.4	19.1	67.5	56.3	7.9
	11-20	0.0	31.5	15.8	45.4	45.3	9.6
	21-31	0.0	31.4	17.9	57.4	48.4	8.1
November	1-10	0.0	33.0	17.8	49.8	31.0	9.0
	11-20	0.0	30.0	12.0	24.9	22.4	8.5
	21-3-	0.0	31.1	13.9	33.7	25.8	7.8
December	1-10	0.0	26.4	13.0	28.6	22.7	6.7
	11-20	0.0	27.0	12.4	24.3	20.4	8.6
	21-31	0.0	26.6	12.4	22.4	22.3	6.7

Source: Meteorological Unit, Institute for Agricultural Research Samaru-Zaria, Nigeria.

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1	St. Patrick's Primary School Maiduguri, Borno State.	1965	1971	1st School Leaving Certificate
2	Govt Secondary School Yerwa, Maiduguri.	1972	1976	WASC (Div. Two)
3	Bauchi College of Arts and Science, Bauchi.	1976	1978	IJMB (Certificate)
4	Ahmadu Bello University, Zaria.	1978	1982	B.Sc (Agriculture) 2nd Class Upper

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St Stephen's Comm. High School, Ado-Odo, Ogun State.	1982	1983	Maths/Agric Science Teacher (NYSC)
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