EFFECT OF SEED SIZE AND PHOSPHORUS LEVELS ON THE GROWTH AND YIELD OF COWPEA (*Vigna unguiculata* [L] w*alp)* VARIETIES

BY

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DECLARATION

I hereby declare that this thesis has been written by me 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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The above declaration is confirmed.

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CERTIFICATION

This thesis titled "*EFFECTS OF SEED SIZE AND PHOSPHORUS LEVELS ON THE GROWTH AND YIELD OF COWPEA (Vigna unguiculata [L.] Walp.) VARIETIES*" by MUSA, Umar Tanko meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is therefore approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to my late father, ALHAJI MUSA ESIKAKU, and "Junior father", A.S.P. ADAMU, Y. MUSA, whose care and inspirations are worth recording on a permanent record.

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ABSTRACT

This experiment was conducted during the rainy season of 1989 in Samaru in Northern guinea Savanna to investigate the effect(s) of seed size and phosphorus levels on the yield and yield components of cowpea *[Vlgna unguicutata [L.] Walp)* varieties. Treatments consisted of two cowpea varieties (improved local S.L 1696 and improved Sampea-7), three seed sizes (large, medium and small) and three phosphorus level (0, 37.5 and 75.0kg $P_2$0c/ha). Possible combination of all the treatments were laid in a split-plot design and replicated three times.

The investigation showed that while large sized seeds produced slightly higher yield and yield components than the remaining two seed sizes, large seed size irrespective of the variety planted produced significantly plants with longer vines, wider leaf area, heavier dry shoot, heavier dry leaf; more leaves all at 4 WAP and more branches at: 8 WAP than the small seed size.

Application of phosphorus slightly decreased the yield and yield components, although these reductions were not statistically significant. Crude protein content of the seed however increased with application of phosphorus (P) fertilizer.

Improved local S.L 1696 variety was more vigorous in vegetative growth than Sampea-7. This variety (Sampea-7)

on the other hand significantly produced higher grain yield (2.62 tons ha"[1]) than improved local S.L 1696 (1.5 tons ha"). Interactive effect of seed size and cowpea variety significantly influenced number of leaves at 4 WAP; branches at 8 and 10 WAP and 100-seed weight at harvest. Improved local S.L 1696 variety irrespective of seed size produced significantly higher number of leaves; and 100-seed weight than Sampea-7.

Grain yield was significantly and positively correlated with yield components (number of flowers, pods, seeds and seed weight per plant) and vegetative growth characters (plant height and leaf area per plant).

From these findings, it can be concluded that grain yield increased by 9.4% when large rather than small seeds were sown. There is therefore no significant yield advantage in selecting large seeds for planting.

Yield and yield components decreased slightly with P-levels, the residual P in the soil as evident from the soil test results, was more than sufficient to raise a good crop of cowpea without P-fertilization. It is therefore a waste of time and resources applying P-fertilizer where soil test results prior to planting reveal high level of residual-P.

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Chapter 1

INTRODUCTION

Cowpea, (*Vigna unguiculata* [*L.*] *Walp*) belongs to the family Leguminosae and sub family Papilionoideae and is widely grown in the drier parts of Africa. Cowpea can be grown profitably on many soils but does best on fertile and well drained, sandy to loam soils.

1.1 Origin and Distribution

All evidence points to cowpea originating in Africa, although where the crop was first domesticated is uncertain. Ethiopia (Vavilov, 1951 and Steele, 1976), Central Africa (Piper, 1913), and West Africa (Fairs, 1965; Steele and Mehra, 1980; Lush and Evans, 1981) have all been considered probable centres of its domestication.

Steele (1976) believed that cowpea was domesticated with sorghum and Pearl millet in Ethiopia because of the close association of these crops in early African Farming. Faris (1965), based on the evidence of the presence of wild Progenitors of cowpeas in West and Central Africa, postulated that West Africa was the centre of domestication of cowpea. This belief is strengthened by the studies of Rawal (1975^{b}), who demonstrated that introgression between wild and cultivated cowpea took place in West Africa, where many forms of wild, weedy and cultivated cowpeas are found. Rawal suggested that cowpeas were domesticated in the subhumid and semi-arid regions of West Africa. This was supported by Steele and Mehra (1980).

Distribution

Vigna unguiculata (L.) Walp is the most diverse of the cultivated species and has the widest distribution. It is commonly called cowpea and is widely grown in Africa, India and Brazil. Varieties are prostrate, semi-erect, erect or climbing and pods are coiled, round, crescent or linear. The wide distribution and early cultivation of cowpea in Asia, where probable wild progenitors are absent, suggests an ancient origin and basic status for it. It is also believed that cowpea reached south western Asia about 2300 BC and came to southern Europe early enough for the Greeks and Romans to grow it under the names of phaseolus (Burkhill, 1953; Purseglove, 1976). It was introduced to the New world in the late 17th century by the Spanish, and more cultivars were transported there from West Africa during the slave trade (Steele, 1976).

1.2 Importance of the Crop

The dietary and agronomic importance of this crop cannot be overemphasized. Cowpea contains between 20-25% protein, which is about 2 - 3 times the protein value of most cereal grains (Bola, 1974). The protein quality is synergistically improved in cereal-legume mixture because of the contribution by cowpea of lysine and methionine by the cereals. Studies of maize-beans mixtures have shown that the quality of the food is highest when food legume contains high levels of sulphur containing amino acids,

which tend to be slightly higher in cowpea than in *Phaseolus vulgaris* (Elias, 1964) but still needs to be improved. Addition of methionine to cowpea protein increases the protein quality significantly, demonstrating the nutritional value of increasing sulphur amino acid content in cowpea protein (Boulter *et al.*, 1975).

The importance of legumes cannot be complete if their role as replenishers of soil introgen is not stressed. The ability of cowpea to fix atmospheric nitrogen via the Rhizobia of the root nodules has made it an important crop in the traditional farming systems (Steele, 1972).

1.3 Production

Despite the importance, and the potential provided by nature for the production of this somewhat noble crop, casual attention is still paid to it in the tropics. Cowpea shows low productivity under traditional farming systems particularly in tropical Africa with dry seed yields of 200-400 $kgha^{-1}$. The low yield is partly attributable to its being cultivated in subsistence agriculture as secondary crop or in association with cereals like sorghum, maize or millet (Rachie and Roberts, 1974; Summer-field *et al.* (1974). Under this situation, the crop will have low nutrient requirements for production. However if grown as sole crop with appropriate management, higher yields could be obtained. Nigeria Federal Department of statistics records (Anon, 1966) suggest that annual

production of cowpea from savanna zones increased from 375,000 tons in 1957-58 to 810,000 tons in 1961-62 and Caswell (1968) estimated that it was one million tons in 1967-68.

High yields of cowpea could be realised with improved management practices. Among the nutrients, the crop is known to respond well to phosphorus application (Yusuf, 1987). Though the P requirement is generally low, P-application has been widely reported to improve nodulation, and seed yield (Kang *et al.*, 1976; Rhodes, 1980; and 1981; Tardieu and Sene, 1966 and Tewain, 1965).

Although the influence of seed size on yields has been known or suspected for many years, there is some disagreement as to its importance. In the past and recent years, many workers including Kiessilbach (1924), Waldron (1941) and Sahabi (1988) have agreed that production from large seed was greater than from small seeds of the same variety. On the other hand, Austin and London, 1967; Harris *et al.*, 1981; Oxemann, 1942; Ezedinma, 1965; and Adelana (1979) agreed that there was an advantage in using large seeds for planting only in the case of short duration species. With advancement in growth this advantage diminished and eventually vanished as the plant ages.

The objectives of the present investigation are therefore as follows:

(i) To determine the effects of seed size on growth and yield of cowpea;

(ii) To determine the effects of different levels of phosphorus on growth and production of cowpea;

(iii) To determine the interaction between i and ii on the growth and yield of cowpea.

Chapter 2

REVIEW OF LITERATURE

2.1 Effect of Seed Size on Crop Production

The effect of seed size on crop development has engaged the attention of research workers for many years. An enormous body of controversial literature on this aspect is available, indicating the need for conducting further detailed investigations.

The literature dealing with large number of crops exhaustively reviewed in 1918 (Brenchley, 1923) supported the conclusion that large seeds give rise to vigorous plants and better yields. There were strong correlations between the size of the germ and the vigour of the resulting seedling and this vigour according to the author continued throughout the life of the plant. Plants from large seeds produced a large number of flowers which produced numerous and large fruits. On the other hand, small seeded soybean types, in order to produce similar yield, were reported to develop 55% more pods than the recurrent parent, despite similar flower production in all the seed size classes (Hartwig and Edward, 1970).

Recent studies on soybean gave conflicting results, some in favour of large seeds and grading of seeds (Burris *et al.*, 1973; Foxtes and Ohlogge, 1972; and Smith and Camper, 1970), others in favour of small and medium seeds (Dhillon,

et al., 1977), while still others gave inconclusive results and indicated the need for additional studies (Tawee, 1972).

In an earlier research Dhillon *et al*.(1976), concluded that large seeds in general appear to take more time for their emergence in accordance with Fick's Second law of Diffusion. The seedling vigour and yield of cereals and legumes (except soybean) seem to be influenced by protein content which is larger in small seeds. But in the case of oil seeds (groundnut and soybean) the reverse appears to be the relation.

Wood *et al.* (1977) also observed that within a seed-lot, using only the large seeds usually results in increased emergence percentages, although occasionally the large seeds perform less when compared to the small ones. Because of their greater embryo size, reserves and early photosynthesis, large seeds produced larger seedlings and the advantage often persists to increase final yield, particularly for short growing season crops or where economic yield is a storage organ or the seed (Wood *et al.*, 1977; Dhillon *et al.*, 1976).

Literature dealing with a large number of crops including cereals, root crops, fodders, leaf crops and cotton was exhaustively reviewed by Kidd and West (1918). The general conclusion drawn were as follows:

> *There were strong correlations between the size of the germ and the vigour of the resulting seedlings. This vigour continued throughout its life, and the plants produced from seeds with the largest germs exhibited higher drought tolerance.*
>
> *The plants from large seeds produced a larger number of flowers which produced more numerous and larger fruits.*
>
> *With increasing age, the superiority of plants from larger seeds decreased, and was gradually lost in perennial plants.*
>
> *In the case of oats, wheat, and rye, higher germination was observed for larger seeds.*
>
> *The interesting outcome of the review was that the growth and yield of the resulting plants were proportional to their initial "Food-capital" following the 'compound interest" Law.*

2.2 Effect of Seed Size on Seedling Establishment

Results of various studies conducted on different crops gave inconclusive results about the viability of different seed sizes.

Greater emergence of small seeds of triticale, barley, maize, green gram, black gram, pigeon pea, cluster beans, and soybean have been reported (Dhillon *et al.*, 1976 *a*,*b*,*c*; and Haskins, 1975) whereas in some studies on soybean, seed size did not show any significant differences on emergence (Johnson, 1974; and Smith, 1975). Large seeds of alfalfa, sweet clower, rice and groundnut, have been reported to give higher germination percentage (Dhillon *et al.*, 1976; Erickson, 1946; Haskins, 1975; and Tseng, 1962). Small seeds of creasted wheat grass and wheat gave practically

the same percentage of emergence, but at lower depths, large seeds gave relatively better emergence than the small seeds (Rogler, 1954; and Schmidt, 1922). Black (1956) and (1957), concluded that there is a direct relationship between seed weight and both dry weight and leaf area in the early plant growth stages. He explained that seedlings from larger seeds have greater initial photosynthetic area leading to increase in dry weight during the early part of vegetative phase. These views were supported by Alam and Locascio (1965), and Austin and Longden (1967).

It would seem from the foregoing that large seeds show superiority over small seeds in producing vigorous seedlings at least at the initial stages of plant development. This is probably due to the presence of large food reserves in the large seeds. This superiority was much pronounced in the case of deeper planting or unfavourable conditions in early stages of growth when seedlings had greater dependence on food reserves of the seed. Under favourable conditions and/or with advance in growth stage, the differences are generally less marked, diminishing and in certain cases completely disappearing (Austin and Longden, 1967 and Harper and Obeid, 1967).

2.3 Effect of Seed Size on Seedling Mortality

Medium seeds of soybean were earlier reported to produce 10% more surviving plants than the seeds of large

or ungraded classes, although these classes gave similar results in viability and vigour tests (Tawee, 1972). Similar results have been obtained in soybean, groundnut, green gram and black gram by Dhillon *et al.* (1976) and in sweet clover by Haskins and Gorz (1975). However, the results of other studies on soybean (Dhillon, 1973 and Smith and Camper, 1975) neither confirm nor refute this results. However, in Pigeon Pea, seedlings from the small seeds showed the lowest mortality (Dhillon *et al.*, 1976), whereas, a reverse trend was reported in creasted wheat grass (Rogler, 1954).

2.4 Effect of Seed Size on Growth and Development

Because of their greater capital (larger embryo and reserves) seedlings from large seeds are almost always heavier, with larger cotyledons than those from small seeds (Black, 1956; Lang and Holmes, 1964; Kaufmann and Guitard 1956; Hewston, 1963) and it will be expected that if plant growth followed the compound interest laws (Blackman, 1919) their advantage would persist at least during the early stages of growth. Black (1956), Lang and Holmes (1964), Scott (1961), Hewston (1963) and Jaggard (1969) have all confirmed this for a wide range of field crops, and all have shown that in the first weeks after emergence relative growth rates were independent of seed size. With isolated plants this advantage in size has often persisted throughout the period of the experiments (Black, 1956; Harper and Obied,

1967). Under field situation, interplant competition will develop sooner in populations growing from larger seed. Thus the advantage of using large seed may diminish and crops from large and small seed may eventually attain similar yields (Wood *et al.*, 1977).

The importance of seed weight seems to be greatest during the earlier stages of plant growth (Oexeman, 1942). The superiority of larger seeds in producing more vigorous and better plants is more pronounced in the case of deeper planting or in unfavourable conditions in the early stages of growth, when the seedlings have a greater dependence on the food reserves of the seed. But under favourable conditions and/or with the advance in growth stage, the differences become less marked; diminishing and in certain cases; completely levelled off (Bremner *et al.*, 1963, Brenchley, 1923; Murphy and Arney, 1939; and Oexeman, 1942) as confirmed by Austin and Longden (1967) and Harper and Obeid (1967).

The results of numerous studies on wheat, harley, crested wheat, native grass species, legume herbage, Alfalfa, sweet clover, soybean, cowpea, and onion indicate that large seeds produced plants of more vigorous growth in the initial stages than those from the small seeds (Baniaa Erickson, 1946; Haskins and Gorz, 1975; Kneeborne and Gramer, 1955; Rogler, 1954; Schmidt, 1922; Ezedinma, 1965 and Cole-Egharevba, 1986). But the early superiority in

favour of seedlings from the large seeds decreased, and in certain cases, eventually lost with the advance in growth stage. But, in the case of black gram, a comparatively short duration crop, the plants from the large seeds, not only maintained their greater height throughout the growing season, but also widened the differences due to their superiority, compared to those from small seeds, with the advance in age.

2.5 Effect of Seed Size on Yield and Yield Compontents

Large seeds of soybean exhibited a superiority over the small seeds in dry matter production of three week old shoots in green house, and 4 weeks old shotts in the growth chamber and in the field. But this superiority was lost with respect to dry weight of shoots, total dry matter production, and shoot-root ratio at 4 weeks of age in the growth chamber. Significantly, taller plants at 3 weeks, and non-significantly taller plants at 4-weeks of age were produced by the large seeds, which led to some increase in the seed weight. These attributes had no significant influence on the grain yield (Dhillon, 1973; Ezedinma; 1965; Cole-Egharevba, 1986 and Adelana (1979).

The results of numerous previous studies on soybean had shown that heavier or larger seeds exhibited superior emergency, embryo size and fresh weight of roots, shoots and total plant weight. They also excelled in vigour,

height, stem diameter, number of branches and pods per plant, dry weight, grain yield and in producing lesser number of barren plants (Burris *et al.*,1971; Burris *et al.*, 1973; Foxtes and Ohlrogge, 1972; Smith and Camper, 1975; Tandon and Gulati, 1968, Tawee, 1972).

In a recent pot culture study by Dhillon *et al*.(1977) with mung bean (ML-1), the dry weight of root at 45 days of age was significantly more in the case of seedlings from small seeds despite their similar height, number of leaves and nodules per plant, dry-weight of shoots, and significantly greater root length of large seed's seedlings. Burris *et al.* (1971) observed that, although larger seeds produced larger embryos, relative dry matter accumulation did not vary appreciably. Subsequently, the same authors in 1973, reported that plants from smaller seeds exhibited higher photosynthetic rates; however, the largest seed size showed greater overall emergence percentage, leaf area and height in the field and yielded significantly more than the small size when grown at uniform populations.

The results of previous studies on wheat, barley and small grain crops showed that large seeds produced slightly taller plants, more tillers, higher number of grains and greater grain and straw yields, when grown on equal number of seeds basis under competition (Borovice, 1965; Dhillon, 1973; Kaufman and Mcfadden, 1960; Randhawa *et al.*, 1969; Randhawa, 1972 and Tawee, 1972). However, when plants were

provided enough spacing for showing their maximum potential, all the seeds produced plants of the same height, same number of tillers and equal grain as well as straw yield (Erickson, 1946).

In another research it was observed that in the case of forage legumes (Carleton and Cooper, 1972), pasture species (Evans, 1973), white clover (Clark and Peck, 1968), milk vetch species (Townsend, 1972) and birdsfoot-trefoil (Twamley, 1974), large seeds performed better. In case of *Brassica campestris* (L.) (cv. Toria), plants from larger seeds produced more fruits per plant, heavier seeds and higher seed yield per plant than those from small seeds, but had fewer seeds per fruit (Ahmed and Zuberi, 1973).

2.6 Effect of Phosphorus on the Growth and Yield of Cowpea

Phosphorus is necessary for photosynthesis, nitrogen fixation, root growth, and nodulation in legumes. In the tropics, phosphorus deficiency and soil acidity are the major factors limiting legume growth and nitrogen fixation (Whitney, 1957). Application of phosphate benefits establishment, persistence, nodulation, and yield of legumes (Whitney, 1975). Tropical legumes fix up to 440kg N/ha/year. According to Hutton (1970) maintenance of a phosphate responsive legume is the cheapest way to provide nitrogen for pasture and grazing animals in the tropics.

Pandy (1968) observed that cowpea grown on sandy soils low in P was stunted and had small dark-green leaves with decrease in the protein-nitrogen 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 phosphorus nutrition. It is therefore not surprising, that, the low P content of the semi-arid soils has been reported as one of the major factors limiting the growth and yield of cowpea in the region (Anon, 1983).

In contrast to these findings, Oliveira *et al.* (1982) observed no significant difference in grain yield due to phosphorus fertilization. The non-response of the cultivars he worked on was attributed to their adaptability to the poor local soils. Other workers have reported similar results as above (Johnson and Evans, 1975), but quite a good number of researchers have written in favour of positive phosphorus effect on cowpea growth and yield. Gill *et al.* (1971) reported that phosphorus application either to soil or as spray, increased the seed yield of cowpea.

Phosphorus has been found not only to increase growth and yields, but also to improve the quality of the crop. Phosphorus fertilization increases the protein content of cowpea significantly (Omueti and Oyenuga, 1970). Similarly Kudikeri *et al.* (1973) reported an increase of about 5% seed

protein content of cowpea as a result of P-fertilization. Kang and Nangju, 1983 also observed that the N, K, Zn, Ca and Mn content of cowpea fodder increased significantly with phosphorus fertilization.

Singh and Jain (1966), observed that application of phosphorus increased the number of branches, dry weight of shoots and nodule number per cowpea plant, but however concluded that other characters remained unaffected. Phosphorus has also been reported to have increased growth, number of leaves per plant, number of fruits per plant, as well as earliness of flowering and increased yields (Kudikeri *et al.*, 1977; Tarila *et al.*, 1977 and Tenebe, 1987). Workers like Laskar and Dadhwal (1981) and Jarayam and Ramia (1980) have all reported decreased pod abscission with P-fertilization in cowpea.

2.7 Effect of Phosphorus Levels on the Yield and Yield Compontents of Cowpea

A first approach to the subject of phsophorus nutrition of plants leads to a consideration of the amounts and rates of absorption. The total amount of phosphorus absorbed can be represented as the product of crop yield times composition. Williams (1948) visualised these factors as wholly not independent of each other, and went further to explain that phosphorus uptake was determined by:

- demand set by the plant and normal functioning of various plants part.

- the external concentration or supply of the nutrient.

Several workers have reported enormous increase in the growth and yields of cowpea on relatively low P-containing soils with increasing P-levels (Kunju *et al.*, 1976; Yayock, 1975; Remison *et al.*, 1980; Yusuf, 1987 and Tenebe, 1987) Gang *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 37.0kg P/ha (85kg P_2O_5/ha) and not by any higher rates. In a research involving four cowpea varieties and four levels of phosphorus, Yusuf (1987) discovered that addition of P led to increases in grain yield and yield components for all varieties. The greatest yield, the author concluded was obtained when 40kg P_2O_5/ha was applied. Agboola and Obigbesan (1977), reported that the highest grain yield was obtained when 30kg P/ha (69kg P_2O_5/ha) was applied irrespective of the P-source. In trials conducted at various locations of savanna ecological zone of Nigeria, it has been found that a rate of 37kg P_2O_5/ha was optimal for seed yield in cowpea (Anon., 1977). As a confirmation of the above fact, it was observed in 1978 that there was no advantage in applying more than 37kg P_2O_5/ha for cowpea seed production in savanna regions of Nigeria (Anon., 1979).

It is important to note that varietal responses to added P also play an important role in determining the

optimum rate of P-required for maximum performance of cowpea. It was reported in 1977, after several trials with phosphorus on cowpea, that interaction between varieties and fertilizer was highly significant (Anon., 1977).

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 dressing of 40kg P/ha (92kg P_2O_5/ha) proved to be the optimum level for seed production in 'New era' variety of cowpea. Kang and Nangju (1983) however observed that 13kg P/ha (30kg P_2O_5/ha) for cowpea in the forest zone of the country was optimal for grain yield.

From the literature reviewed so far, it might be safe at this juncture to conclude that P-recommendaations have to vary with soil properties, native P-content of the soil in question, and even crop variety (Terman, 1971; and Anon., 1977). What ever the shortcomings associated with P-use, Yayock (1975) reported that phosphorus was unquestionably the most important element in cowpea seed production.

Chapter 3

MATERIALS AND METHODS

3.1 Location

The experiment was carried out at the Institute for Agricultural Research Farm - Horticultural garden at Samaru, Zaria, Nigeria, located at 11°11'N latitude and 07°38'E longitude and at an elevation of 686 feet above sea level.

Samaru lies in the Northern Guinea Savanna zone of Nigeria. It has an average annual rainfall of about 1,100mm usually distributed between the months of May and October, with a mean monthly minimum and maximum temperatures of 20°C and 30°C, respectively during the above mentioned period. The soil is moderately deep, well drained and sandy to clayloam in texture.

Results of analysis of the physical and chemical properties of the soil from which the experiment was conducted are presented in Appendix 1. The weather data collected during the 1989 crop growing season are presented in Appendix 2. The history of the soil showed that it was cropped with sweet potato fertilized with 60kg P_2O_5/ha in 1988.

3.2 Treatment and Experimental Design

The treatments consisted of two cowpea varieties (Sampea-7 and S.L 1696), three seed sizes (large, medium and small) and four levels of phosphorus (0, 37.5 and 75.0kg P_2O_5/ha) using single superphosphate (18% P_2O_5) as P source.

The treatments were arranged and laid out in split-plot design with three replications. The main and subplots measured 27.00m^2 and 9.0m^2 respectively. The main plot consisted of 12 ridges of 75cm width and 300cm long, while the subplots contained four ridges. The cowpea varieties and phosphorus were allocated to the main plots, while the seed size went into the subplots.

3.3 Grading of the Seeds

Seeds from the two cowpea varieties (Sampea-7 and 1696) were selected and graded into three sizes by visual observation. These were later graded using round perforated metal sieves having different hole diameters at the Department of Civil Engineering, Ahmadu Bello University, Zaria. The sizes used for Sampea-7 were: Large = those seeds with diameter greater than 6.6mm mesh (>6.6mm); Medium = those seeds that passed through the screen with 6.6mm but retained on a mesh of 6.22mm (medium = 6.6 to 6.22) and Small = those that passed through the 6.22mm mesh (small <6.22mm). The sizes used for improved local 1696

were: Large = those seeds with diameter greater than 7.51mm mesh (large >7.51mm); Medium = those seeds that passed through the screen with 6.72mm mesh (medium = 7.51 to 6.72mm); and Small = representing those seeds that passed through 6.72mm mesh. One hundred (100) seeds of the three sizes from the two different varieties were then sampled and weighed.

Variety	Seed sizes (100 seeds) gms		
	Large	Medium	Small
S.L. 1696	28.00	22.00	16.00
Sampea-7	21.00	16.00	13.00

3.4 Field Operations

3.4.1 Soil sampling and analysis

Soil samples were collected from randomly selected spots on the field. Samples were taken at two depths (0-15cm and 15-30cm) using a tubular auger, prior to planting of the experiment. These were then analysed for both chemical and physical properties (Appendix 1).

3.4.2 Soil pH

Soil pH was determined in water and 0.01M $cacl_2$, using a soil solution ratio of 1 : 2, by means of a philip analogue pH meter.

3.4.3 Organic carbon

The organic carbon content of the soils was determined by chromic acid method (Allison, 1965).

3.4.4 Exchangeable bases

The exchangeable bases were extracted with neutral 1N NH_4OAC. Extracted K and Na were determined by flame emission photometry while Ca and Mg were determined by atomic absorption spectrophotometry (Heald, 1965; Pratt, 1965a; Pratt, 1965b).

3.4.5 Cation exchange capacity (CEC)

CEC was determined by ammonium saturation method. The soil residue after extraction with neutral ammonium acetate was washed with 1N NH_4CL and then with ethanol. The ammonium ions were absorbed in boric acid by distillation and titrated with standard sulphuric acid.

3.4.6 Particle size analysis

Particle size distribution was determined by the hydrometer method using calgon as a dispersing agent (Day, 1965). The classification was done according to the American System using a standard textural triangle.

3.4.7 Available P

Olsen Method: Five grams of soil, 100ml of extraction solution (0.5m $NaHCO_3$ at pH 8.5) and one teaspoon of carbon black (Darco G60 quality) were added to an extraction bottle and shaken for 30 minutes on an end-to-end shaker. The clear extract was obtained by filtering through watchman No. 42 filter paper and extracted P was determined colorimetrically by the ammonium molybdate - stannous chloride method at 660mm incident light (Olsen *et al.*, 1954).

3.4.8 Total nitrogen in soils

Ten grammes of each of the soil samples were soaked in 50ml of distilled water for 30 minutes. 50ml of concentrater H_2SO_4 - salicylic acid mixture and 5gm of sodium thiosulphate were added to each and heated gently for five minutes. Thereafter about 10gm Kjeldahl catalyst (Ce, $CuSO_4$ and Ba_2SO_4 in the ratio of 1 : 1 : 10 respectively) and four glass cooling beads were added and the mixture digested until the other solution became clear. Digestion was continued for one more hour. 100ml of distilled H_2O were added to the digest. The NH_3 formed was liberated by adding 50ml of 45% NaOH solution and distilling into 50ml of 2% boric acid until 100ml of distillate were collected. The NH_3 trapped in the boric acid was determined by titrating with 0.1N H_2SO_4 using bromocresol green-methyl red indicator (Bremner, 1965).

3.4.9 Land preparation

The land was ploughed, harrowed to a fine tilth and ridged at 75cm width. The field was marked out into 54 plots of $9.0m^2$ (3.0m x 3.0m) size each. Each main plot which measured 3 x $9m^2$ was separated from the adjacent one by means of a metre path.

3.4.10 Planting and planting material

The crop was planted on the 19th of July, 1989. Two varieties of cowpea, semi-improved local (S.L[+] 1696) and Sampea-7 were used. S.L 1696 is a creeping, semi-improved variety, while Sampea-7 is an upright, improved and photo-period insensitive variety.

Three seeds from each of the three seed sizes were planted at 25cm apart and to a depth of 2.5cm.

3.4.11 Fertilizer application

Single superphosphate (18.0% P_2O_5) was hand applied at 0, 37.5 and 75.0kg/ha to each of the main plots with the exception of the control plots.

3.4.12 Thinning

The crop was thinned (4 weeks after planting) to two plants per stand on plots where the three seeds sown per

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[+] *S.L means semi-local.*

hole germinated. During the thinning process only the weakest of the three plants was destroyed.

3.4.13 Weed and pest control

Galex 500 EC (Metolachlor + metobromuron) a pre-emergence herbicide was used at 5L/ha (2.5kg ai/ha) to suppress weed growth. This was applied a day after sowing. One supplementary hoe-weeding was done at 6 weeks after sowing to check weed growth.

To control insects pests, a mixture of Cymbush (Cypermethrin) 10 EC and Rogor (dimethoate) 40 EC was applied at the rate of 500ml of each chemical in 100 litres of water per hectare using a CP-3 knapsack sprayer. Spraying started 4 weeks after sowing mainly to protect the crop against bettles and some aphids. During podding the frequency of spraying was increased from 2-week interval to weekly operation as a means of checking the notorious activities of pod sucking insects - bugs.

As a means of controlling fungus infections, Benlate (50% W.P) + Dithane M45 were used at a rate of 0.6kg + 2.5kg each respectively of the chemicals in 400 litres of water/ha, starting from four weeks after sowing and continued at two weeks interval until the crop matured.

3.4.14 Harvesting

Sampea-7 was harvested 11.5 weeks after planting, while harvesting of S.L 1696 variety took place three weeks later. Each net plot was harvested into separate labelled bags for ease of identification.

3.5 Observation and Data Collection

3.5.1 Assessment of pre-harvest parameters

With the exception of stand count that was taken 6-days after sowing, all other parameters such as - number of leaves, number of branches, plant height, leaf area, leaf dry wt, and shoot dry weight per plant began 4 weeks after sowing. Subsequent samplings were taken at two-weekly intervals.

Four plants were randomly selected from each plot for analysis. To ensure for accuracy, the plants were carefully uprooted and washed before any study was carried out on them. The length of the plants was taken by measuring the vine from the point of emergence from the soil to the highest vertical apex with the aid of a ruler. Number of leaves and branches per plant were taken by simple count, while the leaf area was determined by measuring the areas of the middle leaflets and multiplying by a constant factor of 2.7 or 1/0.37 as described by Nangju and Wanki (1979).

3.5.1.1 Stand count

Number of seeds that germinated from each of the plots were assessed 6-days after planting by simple count. The value obtained was then expressed as a fraction of the total number of seeds planted. The fraction was then expressed in percentage.

3.5.1.2 Number of days to first flowering

Daily observations were made at 7.30 a.m every day starting from 5 WAP until first flower was seen. This observation continued until the whole plots flowered.

3.5.1.3 Days to 50% flowering

After the first flower was observed, subsequent flower produced was counted until 50% of the plants flowered. The date half the plants population on a plot flowered was recorded as the number of "days to 50% flowering" for that particular plot.

3.5.1.4 Number of flowers per plant

Four plants per plot were permanently tagged for this purpose. The number of flower(s) that opened were/was counted for each of the tagged plants and for every plot until the plants seized to produce flower.

3.5.2 Assessment of post harvest parameters

Number of pods per plant, number of seeds per pod, number of seeds per plant, weight of 100 seeds, threshing percent and determination of crude protein content were all carried out immediately after harvest.

3.5.2.1 Number of pods per plant

The four plants that were tagged as described above, were also used to determine the average number of pods produced per plant.

3.5.2.2 Number of seeds per pod

Ten pods were randomly selected from each of the plots, and the number of seeds produced per pod was then counted. The average number of seeds produced for the ten pods was then obtained by dividing by ten (10).

3.5.2.3 Number of seeds per plant

Four plants were separately harvested, threshed and the total number of seeds counted. The total number of seeds obtained for the four plants was then averaged.

3.5.2.4 Weight of 100-seed

A handful of the threshed cowpea grain was randomly drawn from each plot, these samples were then counted for 100-seed. The weight of the hundred seeds was then taken

using an electronic "mettler P1210" weighing scale.

3.5.2.5 Threshing percent

The threshing percentage for each of the plot was determined by dividing the threshed weight of the cowpea by the unthreshed weight and finally multiplied by 100.

$$\text{Threshing \%} = \frac{\text{Threshed grain weight}}{\text{Unthreshed grain weight}} \times 100$$

3.5.2.6 Crude protein content

The nitrogen content of the threshed seeds was determined by the standard micro Kjeldahl procedure, as described by the Association of Official Analytical Chemists (A.O.A.C., 1975). The samples were dried at 60 - 70°C overnight and then ground to pass through a one millimetre mesh sieve. A sample (40 - 50mg) was taken and digested with concentrated sulphuric acid in the presence of $CuSO_4$ and Na_2SO_4 catalysts. The mixture was then distilled into boric acid and the distillate titrated against a standard hydrochloric acid. The percent nitrogen obtained from the titre, was then multiplied by 6.25 to give the % crude protein.

3.5.3 Analysis of data

The data collected were subjected to analysis of variance as described by Snedecor and Cochran (1967).

Duncan's Multiple Range Test (DMRT) was used to compare the means for significant differences as described by Duncan (1955).

Chapter 4

RESULTS

4.1 Effects of Seed Size and Phosphorus Levels on the Growth of Cowpea

4.1.1 Germination count

The results obtained indicated that, germination count was not significantly affected by the levels of phosphorus applied per hectare, and cowpea variety (Table 4.1). However, seed size significantly affected germination count. The large sized seeds gave significantly higher germination count (79.5%) than small sized seeds (72.94%) but this was not significantly different from the medium sized seeds (77.94%). The difference between small and medium seed sizes was however significant.

The interactive effects of seed size and levels of phosphorus and cowpea variety on germination count were not significant.

4.1.2 Plant height

Plant height was significantly influenced by seed size at 4 weeks after planting and cowpea variety at 6 and 10 weeks after planting, while levels of phosphorus applied per hectare had no significant effect (Table 4.2).

Table 4.1: Effect of seed size and phosphorus levels on germination percent and stand count at harvest of cowpea at Samaru in 1989.

Treatment	Germination (%)	Stand count at harvest
Seed size		
Small	72.94c	80.33
Medium	77.94ab	79.00
Large	79.50a	79.56
S.E (±)	2.49	1.71
Significance	*	N.S
Phosphorus levels ($kgha^{-1}$)		
0	79.33	78.11
37.5	78.39	78.44
75.0	77.67	82.33
S.E (±)	2.49	1.71
Significance	N.S	N.S
Varieties		
S.L 1696	75.26	80.37
Sampea-7	78.33	78.89
S.E (±)	2.03	1.39
Significance	N.S	N.S
Interactions		
P x S	N.S	N.S
P x V	N.S	N.S
V x S	N.S	N.S
P x V x S	N.S	N.S

Mean followed by the same letter(s) within a treatment group for a particular character are not significant statistically (using DMRT).

*N.S = Not significant; * and ** = Significant at 5 and 1 percent, respectively.*

Table 4.2: Vine length of cowpea plants (cm) as influenced by seed size and phosphorus levels at Samaru in 1989.

Treatment	Weeks after planting (WAP)			
	4	6	8	10
Seed size				
Small	14.09c	42.79	89.17	117.69
Medium	16.14b	44.88	98.69	122.00
Large	17.15a	51.36	103.28	130.86
S.E (±)	0.23	2.99	6.78	7.94
Significance	*	N.S	N.S	N.S
Phosphorus levels ($kgha^{-1}$)				
0	15.91	52.07	100.5	122.89
37.5	15.85	44.00	93.08	116.81
75.0	15.62	42.96	92.56	115.86
S.E (±)	0.23	2.99	0.78	7.94
Significance	N.S	N.S	N.S	N.S
Varieties				
S.L 1696	16.34	49.86a	98.63	137.40a
Sampea-7	15.25	42.82b	95.46	109.65b
S.E (±)	0.19	2.45	5.53	6.48
Significance	N.S	*	N.S	**
Interactions				
P x S	N.S	N.S	N.S	N.S
V x S	N.S	N.S	N.S	N.S
P x V	*	N.S	N.S	N.S
P x V x S	N.S	N.S	N.S	N.S

Means followed by the same letter(s) within a treatment group for a particular character are not significant statistically (using DMRT).

*N.S = Not significant; * and ** = Significant at 5 and 1 percent, respectively.*

Plant height increased with increase in seed size. Large seeds produced the tallest plants, followed closely by medium sized seeds. The small sized seeds gave the shortest plants throughout the sampling period.

The improved local 1696 variety was significantly taller than Sampea-7 throughout the sampling period except at 6 and 10 weeks after planting.

The interaction between phosphorus levels and cowpea variety on plant height was only significant at 4 weeks after planting (Table 4.3).

Table 4.3: Interactive effect of phosphorus levels and cowpea variety on vine length per plant at 4 weeks after planting at Samaru in 1989.

Phosphorus levels	Cowpea varieties	
	S.L 1696	Sampea-7
0 - level	16.52a	15.29b
37.5 kg/ha	16.89a	15.64b
75.0 kg/ha	15.59b	14.81b
S.E (±)	0.33	

The control and treated plots produced statistically similar plant height for both Sampea-7 and S.L 1696 varieties at 75.0kg P per hectare. The difference between the control and 37.5kg P/ha for S.L 1696 variety, even though not significant, was significantly different from 75.0kg P/ha level.

4.1.3 Number of leaves per plant

The number of leaves produced per plant was significantly influenced by seed size at 4 weeks after planting, and by cowpea variety throughout the sampling period (Table 4.4). Large sized seeds produced more leaves per plant than medium or small seeds throughout the sampling period. The plants from the controlled plots had higher number of leaves per plant than the treated plots (Table 4.4). The number of leaves/plant decreased progressively as phosphorus level increased. This decrease was however not significant. Improved local variety (S.L 1696) produced significantly higher number of leaves per plant than Sampea-7.

Interactive effect of seed size and cowpea variety on number of leaves per plant at 4 weeks after planting was significant (Table 4.5). Variety S.L 1696 irrespective of seed size produced significantly higher number of leaves than improved Sampea-7. Large and medium seeds of Sampea-7 produced similar number of leaves which are significantly different from small sized seeds.

4.1.4 Total leaf area (cm^2) per plant

The total leaf area per plant was significantly influenced by the seed size at 4 weeks after planting and cowpea variety at 6 and 10 weeks after planting. Level of

Table 4.4: Number of leaves per plant of cowpea as influenced by seed size, phosphorus levels and variety at Samaru in 1989.

Treatments	Weeks after Planting (WAP)			
	4	6	8	10
Seed size				
Small	22.26b	81.39	149.11	122.83
Medium	22.78b	90.39	171.61	163.17
Large	27.09a	97.72	171.83	184.83
S.E (±)	1.10	4.64	11.57	14.23
Significance	*	N.S	N.S	N.S
Phosphorus levels ($kgha^{-1}$)				
0	25.32	95.11	164.50	141.06
37.0	23.97	90.33	166.39	160.50
75.0	22.85	84.33	161.67	125.28
S.E (±)	1.10	4.64	11.57	14.24
Significance	N.S	N.S	N.S	N.S
Variety				
S.L 1696	28.56a	98.56a	198.48a	185.22a
Sampea-7	19.53b	81.11b	129.89b	99.33b
S.E (±)	0.89	3.79	9.44	33.45
Significance	**	**	**	**
Interactions				
P x S	N.S	N.S	N.S	N.S
V x S	*	N.S	N.S	N.S
P x V	N.S	N.S	N.S	N.S
P x V x S	N.S	N.S	N.S	N.S

Means followed by the same letter(s) within a treatment group for a particular character are not significant statistically (using DMRT).

*N.S = Not significant; * and ** = Significant at 5 and 1 percent, respectively.*

phosphorus applied per hectare however had no significant effect on leaf area (Table 4.6).

Table 4.5: Interactive effect of seed size and cowpea variety on number of leaves produced per plant at 4 weeks after planting at Samaru in 1989.

Seed size	Cowpea varieties	
	S.L 1696	Sampea-7
Small	24.59c	17.97e
Medium	27.59b	19.93de
Large	33.48a	20.71d
S.E (±)	6.56	

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

Large sized seeds gave higher leaf area per plant than either medium or small seeds throughout the sampling period. Even though the difference in total leaf area per plant was only significant at 4 weeks after planting, the difference between the small and medium seeds was not statistically significant.

Total leaf area per plant decreased with increase in phosphorus level, and at 10 WAP a significant decrease was observed.

Table 4.6: Total leaf area (cm^2) per plant of cowpea as influenced by seed size and phosphorus levels at Samaru in 1989.

Treatment	Weeks After Planting (WAP)			
	4	6	8	10
Seed size				
Small	560.65b	2880.15	5149.91	3699.04
Medium	607.83b	2913.38	5603.83	4444.50
Large	718.97a	2975.24	5009.65	3905.76
S.E (±)	29.85	289.47	465.04	445.74
Significance	**	N.S	N.S	N.S
Phosphorus levels ($kgha^{-1}$)				
0	654.16	3219.35	5429.71	3510.79
37.5	620.36	3048.96	5424.00	4965.68
75.0	612.92	2500.46	4909.68	3572.83
S.E (±)	29.85	289.47	465.04	445.74
Significance	N.S	N.S	N.S	N.S
Varieties				
S.L 1696	644.36	3273.91a	5312.63	4692.90a
Sampea-7	613.94	2571.93b	5996.29	3339.97b
S.E (±)	24.38	236.35	379.70	363.94
Significance	N.S	*	N.S	*
Interactions				
P x S	N.S	N.S	N.S	N.S
V x S	N.S	N.S	N.S	N.S
P x V	N.S	N.S	N.S	N.S
P x V x S	N.S	N.S	N.S	N.S

Means followed by the same letter(s) within a treatment group for a particular character are not significant statistically (using DMRT).

*N.S = Not significant; * and ** = Significant at 5 and 1 percent, respectively.*

The improved local 1696 variety produced higher leaf area than Sampea-7 throughout the sampling period, but this difference was not significant except at 6 and 10 WAP.

The interactive effect of seed size, levels of phosphorus, and cowpea variety on total leaf area per plant was not significant.

4.1.5 Number of branches per plant

Number of branches per plant was significantly influenced by seed size at 8 weeks after planting only, and cowpea variety at 8 and 10 weeks after planting. Phosphorus however, had no significant influence on the number of branches per plant (Table 4.7). Number of branches produced per plant increased with seed size throughout the sampling period. Large sized seeds produced significantly higher number of branches than medium or small seeds at 8 WAP but the difference between the small and medium seeds was not statistically significant at 8 WAP.

Number of branches produced per plant declined with increased phosphorus level.

Sampea-7 variety produced higher number of branches throughout the sampling period than S.L 1696, but significantly only at 8 and 10 weeks after planting.

Table 4.7: Number of branches per plant of cowpea as influenced by seed size and phosphorus levels at Samaru in 1989.

Treatment	Weeks after Planting (WAP)			
	4	6	8	10
Seed size				
Small	2.22	4.94	9.73b	15.06
Medium	2.33	5.61	9.89b	14.50
Large	2.72	5.28	14.0a	13.06
S.E (±)	0.18	0.28	1.27	0.93
Significance	N.S	N.S	*	N.S
Phosphorus levels ($kgha^{-1}$)				
0	2.56	5.28	12.44	14.11
37.5	2.56	5.25	10.78	14.61
75.0	2.17	5.44	10.39	13.89
S.E (±)	0.18	0.28	1.27	0.93
Significance	N.S	N.S	N.S	N.S
Varieties				
S.L 1696	2.22	5.19	7.89	9.07b
Sampea-7	2.33	5.37	14.52a	19.33a
S.E (±)	0.15	0.23	0.04	0.76
Significance	N.S	N.S	**	**
Interactions				
P x S	N.S	N.S	N.S	N.S
V x S	N.S	N.S	*	*
P x V	N.S	N.S	N.S	N.S
P x V x S	N.S	N.S	N.S	N.S

Means followed by the same letter(s) within a treatment group for a particular character are not significant statistically (using DMRT).

*N.S = Not significant; * and ** = Significant at 5 and 1 percent, respectively.*

The interactive effect of seed size and cowpea variety on number of branches per plant was significant at 8 and 10 weeks after planting (Table 4.8). Small, medium and large seeds of S.L 1696 produced statistically similar number of branches per plant as the small and medium sized seeds of Sampea-7 but produced significantly different number of branches from the large sized seeds of the same variety at 8 WAP. The same pattern of interaction was also observed at 10 WAP (Table 4.8).

Table 4.8: Interactive effect of seed size and cowpea variety on number of branches produced per plant at 8 and 10 weeks after planting at Samaru in 1989.

Seed size	Weeks after Planting			
	8 weeks		10 weeks	
	Cowpea variety			
	S.L 1696	Sampea-7	S.L 1696	Sampea-7
Small	7.78b	11.56b	8.00c	17.78b
Medium	7.89b	12.00b	8.89c	18.11b
Large	8.00b	20.00a	10.89c	22.11a
S.E (±)	1.79		1.31	

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

4.1.6 Shoot dry weight (g) per plant

Shoot dry weight per plant was significantly influenced by seed size at 4 WAP (Table 4.9). P-application

Table 4.9: Shoot dry weight (gms) per plant of cowpea as influenced by seed size and phosphorus levels at Samaru in 1989.

Treatment	Weeks after Planting (WAP)			
	4	6	8	10
Seed size				
Small	1.11b	6.17	18.90	38.59
Medium	1.17b	6.87	21.30	30.82
Large	1.42a	7.71	22.04	31.68
S.E (±)	6.29	0.51	1.75	2.25
Significance	*	N.S	N.S	N.S
Phosphorus level ($kgha^{-1}$)				
0	1.28	7.32	21.14	32.21
37.5	1.22	7.19	20.96	29.94
75.0	1.19	6.24	20.13	28.94
S.E (±)	6.29	0.51	1.75	2.25
Significance	N.S	N.S	N.S	N.S
Varieties				
S.L 1696	1.42a	7.16	22.28	29.46
Sampea-7	1.05b	6.67	19.21	27.60
S.E (±)	5.14	0.42	1.43	1.83
Significance	*	N.S	N.S	N.S
Interactions				
P x S	N.S	N.S	N.S	N.S
V x S	N.S	N.S	N.S	N.S
P x V	N.S	N.S	N.S	N.S
P x V x S	N.S	N.S	N.S	N.S

Means followed by the same letter(s) within a treatment group for a particular character are not significant statistically (using DMRT).

*N.S = Not significant; * and ** = Significant at 5 and 1 percent, respectively.*

and cowpea variety had no significant effect on shoot dry weight. Large sized seeds produced significantly heavier plants than either small or medium seeds at 4 weeks after planting. Medium and small sized seeds produced similar shoot dry weights. Increasing levels of phosphorus slightly decreased shoot dry weight per plant.

S.L 1696 variety produced heavier dry shoots per plant throughout the sampling period, but this difference was not significant except at 4 WAP.

The interactive effects of seed size, phosphorus levels and cowpea variety on shoot dry weight were however not significant.

4.1.7 Leaf dry weight per plant

Leaf dry weight per plant was significantly influenced by seed size at 4 WAP (Table 4.10), while levels of phosphorus applied per hectare had no significant effect on the leaf dry weight except at 10 WAP.

Cowpea variety had significant influence on leaf dry weight at 4 and 10 WAP.

Leaf dry weight significantly increased linearly with seed size at 4 WAP.

S.L 1696 variety consistently produced heavier leaf dry weight than the improved Sapea-7 variety throughout the sampling period.

Table 4.10: Lead dry weight (gm) per plant of cowpea as influenced by seed size and phosphorus levels at Samaru in 1989.

Treatment	Weeks after Planting (WAP)			
	4	6	8	10
Seed size				
Small	2.45c	12.25	22.22	16.49
Medium	2.65b	12.59	24.62	19.73
Large	3.13a	12.79	24.67	17.32
S.E (±)	0.12	1.19	2.09	1.96
Significance	*	N.S	N.S	N.S
Phosphorus level ($kgha^{-1}$)				
0	2.85	13.80	23.30	15.68b
37.5	2.71	13.24	23.83	15.89b
75.0	2.66	10.59	21.22	21.96a
S.E (±)	0.12	1.19	2.09	1.96
Significance	N.S	N.S	N.S	*
Varieties				
S.L 1696	3.07a	12.84	25.07	22.55a
Sampea-7	2.41b	12.25	20.50	13.14b
S.E (±)	0.10	0.97	1.71	1.60
Significance	*	N.S	N.S	**
Interactions				
P x S	N.S	N.S	N.S	N.S
V x S	N.S	N.S	N.S	N.S
P x V	N.S	N.S	N.S	N.S
P x V x S	N.S	N.S	N.S	N.S

Means followed by the same letter(s) within a treatment group for a particular character are not significant statistically (using DMRT).

*N.S = Not significant; * and ** = Significant at 5 and 1 percent, respectively.*

The interactive effect of seed size, phosphorus levels and cowpea variety on leaf dry weight was not significant.

4.2 Effect of Seed Size and Levels of Phosphorus on the Yield and Yield Components of Cowpea

4.2.1 Grain yield (kg/ha)

Large seeds produced higher grain yield than the rest of the seed classes but the difference was not significant (*Table 4.11*).

Plots were phosphorus was not applied produced the highest yields of grain (2146.65 kg/ha), while application of 37.5kg P/ha yielded 2141.76kg grain/ha. The lowest yield of 2014.58kg grain per hectare was obtained when 75.0kg P/ha was applied. This observation might not be unconnected with the high residual level of phosphorus in the soil prior to the conduct of the experiment.

Sampea-7 produced significantly higher seed yield (2616.59 kg/ha) than improved local S.L 1696 variety (1585.41 kg/ha).

The interaction of seed size, levels of phosphorus and cowpea variety on the grain yield was not significant (Table 4.11).

Table 4.11: Effect of seed size and phosphorus level on the grain yield, threshing percentage and percent crude protein of cowpea at Samaru in 1989.

Treatment	Yield kgha^{-2} (threshed)	Threshing (%)	% crude protein
Seed size			
Small	2041.93	78.33	24.57
Medium	2125.81	78.06	24.83
Large	2235.21	79.78	23.88
S.E (±)	107.33	79.78	0.46
Significance	N.S	N.S	N.S
Phosphorus levels (kgha^{-1})			
0	2146.65	75.56c	23.41b
37.5	2141.76	79.56b	24.96a
75.0	2014.58	81.06a	24.97a
S.E (±)	107.33	1.19	0.46
Significance	N.S	*	*
Varieties			
S.L 1696	1585.41b	80.85a	24.62
Sampea-7	2616.59a	76.59b	24.23
S.E (±)	87.64	0.97	0.38
Significance	**	**	N.S
Interactions			
P x S	N.S	N.S	N.S
V x S	N.S	N.S	N.S
P x V	N.S	*	N.S
P x V x S	N.S	N.S	N.S

Means followed by the same letter(s) within a treatment group for a particular character are not significant statistically (using DMRT).

*N.S = Not significant; * and ** = Significant at 5 and 1 percent, respectively.*

4.2.2 Threshing percentage (%)

Threshing percent was significantly influenced by both phosphorus levels and cowpea variety (Table 4.11), but seed size had no significant influence on this character.

Application of 75kg P_2O_5/ha produced cowpea of statistically similar threshing % as 37.5kg P_2O_5/ha (Table 4.11). The controlled plots however produced cowpea with threshing % significantly higher than either of the treated plots.

Improved local S.L 1696 variety had a significantly higher threshing % (80.85%) than Sampea-7 variety (76.59%).

Interactive effect of phosphorus levels and cowpea variety on threshing % was significant (Table 4.12). With the exception of Sampea-7, where the untreated plots produced cowpea of significantly lower threshing % than the treated plots, S.L 1696 variety on the other hand gave statisticallly similar threshing % for both the controlled and treated plots (Table 4.12).

4.2.3 Crude protein content

Percent crude protein was not significantly influenced by seed size and cowpea variety. However, phosphorus significantly influenced this character (Table 4.11).

Treated plots produced cowpea of higher crude protein than those of controlled plots. There was however no significant difference between the treated plots.

Table 4.12: Interactive effect of phosphorus levels and cowpea variety on threshing percentage at Samaru in 1989.

Treatment	Cowpea variety	
	S.L 1696	Sampea-7
Phosphorus levels ($kgha^{-1}$)		
0	80.56a	70.56b
37.5	80.89a	78.00a
75.0	81.11a	81.22a
S.E (±)	1.68	

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

None of the interactive effects of seed size, phosphorus levels and cowpea variety on crude protein content was significant.

4.2.4 Number of days to first flowering

Number of days to first flowering was not in any way affected by levels of phosphorus, but seed size significantly affected number of days to first flowering (Table 4.13). The large sized seeds flowered one day earlier than medium and small seed sizes. The number of days to

Table 4.13: Effect of seed size and phosphorus levels on number of days to first flowering, number of days to 50% and number of flower per plant of cowpea at Samaru in 1989.

Treatment	No. of days to first flowering	No. of days to 50% flowering	No. of flower per plant
Seed size			
Small	58.44a	64.50	30.05
Medium	58.28a	64.11	34.09
Large	57.22b	63.61	33.43
S.E (±)	0.23	0.72	2.63
Significance	**	N.S	N.S
Phosphorus levels ($kgha^{-1}$)			
0	58.22	62.89	33.66
37.5	57.61	64.56	33.94
75.0	58.11	64.78	29.98
S.E (±)	0.23	0.72	2.63
Significance	N.S	N.S	N.S
Varieties			
S.L 1696	73.82a	75.85a	25.18b
Sampea-7	42.15b	52.30b	39.87a
S.E (±)	0.19	0.59	2.14
Significance	**	**	**
Interactions			
P x S	N.S	N.S	N.S
V x S	N.S	N.S	N.S
P x V	N.S	*	N.S
P x V x S	N.S	N.S	N.S

Means followed by the same letter(s) within a treatment group for a group for a particular character are not significant statistically (using DMRT).

*N.S = Not significant; * and ** = Significant at 5 and 1 percent, respectively.*

first flowering for medium and small seed sizes were not different. The photo-period insensitive variety (Sampea-7) flowered much earlier (42 days) than the photo-period sensitive S.L 1696 variety (74 days), this difference due to variety was however highly significant (Table 4.13).

The interactive effects of seed size, phosphorus levels and cowpea variety on number of days to first flowering were not significant.

4.2.5 Number of days to 50% flowering

Neither seed size nor phosphorus level had significant effect on number of days to 50% flowering, but varietal differences was highly evident (Table 4.13). As with the number of days to first flowering, the number of days to 50% flowering was significantly earlier for a Sampea-7 variety, while the improved local 1696 variety took longer number of days to attain 50% flowering.

The interactive effects of phosphorus levels and cowpea variety on number of days to 50% flowering was highly significant (Table 4.14). There was no significant difference in the days it took S.L 1696 variety to reach 50% flowering as the phosphorus level increased. The controlled plots of Sampea-7 took significantly less number of days (50 days) to 50% flowering than either of the treated plots (54 days). The difference between 37.5kg and 75.0kg P_2O_5/ha with respect to days to 50% flowering was not significant.

Table 4.14: Interactive effect of phosphorus levels and cowpea variety on number of days to 50% flowering.

Treatment	Cowpea variety	
	S.L 1696	Sampea-7
Phosphorus levels ($kgha^{-1}$)		
0	76.22a	49.56c
37.5	75.22a	53.89b
75.0	76.11a	53.44b
S.E (±)	1.01	

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

Neither seed size nor phosphorus level had any significant influence on number of flowers produced per plant, but cowpea variety significantly influenced this character (Table 4.13), indicating that this variable is highly genetically controlled.

Variety S.L 1696 significantly produced lower number of flowers per plant (25.18) than improved Sampea-7 (39.87) variety.

The interactive effects of seed size, phosphorus levels and cowpea variety on the number of flowers per plant were not significant.

4.2.7 Number of seeds per pod

Number of seeds per pod was not affected by seed size, but phosphorus level and cowpea variety significantly influenced it (Table 4.15). The highest number of seeds per pod (12.0 seeds) was obtained when 37.5kg P_2O_5 was applied per hectare. There was however no significant difference between the control and 75.0kg P_2O_5/ha with respect to the number of seeds/pod (11 seeds).

S.L 1696 variety significantly produced more seeds (12.0 seeds) per pod than Sampea-7 variety (11.0 seeds).

The interactive effect of seed size, phosphorus levels and cowpea variety on number of seeds/pod was not significant.

4.2.8 Number of of pods per plant

Number of pods per plant was not in any way influenced by either seed size nor phosphorus levels, but was significantly affected by cowpea variety (Table 4.15).

The variety Sampea-7 produced significantly more pods (29 pods/plant) than variety S.L 1696.

The interaction of seed size, phosphorus level and cowpea variety on number of pods produced per plant was also not significant.

Table 4.15: Effect of seed size and phosphorus levels on some yield components of cowpea varieties at Samaru in 1989.

Treatment	No. of seed/ pod	No. of pods per plant	No. of seeds/ plant	Wt. of seed per plant (gm)	100-seed wt (gm)
Seed size					
Small	11.94	21.78	255.67	36.90	17.45c
Medium	11.44	24.94	293.50	40.26	18.17b
Large	11.28	24.22	286.61	42.23	18.99a
S.E (±)	0.27	1.86	22.99	1.37	0.31
Significance	N.S	N.S	N.S	N.S	*
Phosphorus levels ($kgha^{-1}$)					
0	11.17b	24.39	289.28	18.90	17.96
37.5	12.11a	24.83	291.33	18.47	18.00
75.0	11.39b	21.72	255.17	16.50	18.65
S.E (±)	0.27	1.86	22.99	1.37	0.31
Significance	*	N.S	N.S	N.S	N.S
Varieties					
S.L 1696	11.96a	18.41b	239.41b	43.41b	21.30a
Sampea-7	11.15b	28.89a	317.78a	46.50a	15.11b
S.E (±)	0.22	1.52	18.78	1.12	0.25
Significance	*	**	*	**	**
Interaction					
P x S	N.S	N.S	N.S	N.S	N.S
V x S	N.S	N.S	N.S	N.S	*
P x V	N.S	N.S	N.S	N.S	N.S
P x V x S	N.S	N.S	N.S	N.S	N.S

Means followed by the same letter(s) within a treatment group for a particular character are not significant statistically (using DMRT).

*N.S = Not significant; * and ** = Significant at 5 and 1 percent, respectively.*

4.2.9 Number of seeds per plant

Even though the number of seeds produced per plant increased with seed size, the difference was not significant. Levels of phosphorus applied also had no significant effect on the number of seeds produced per plant but variety significantly influenced this character - Genetically set.

Sampea-7 produced more seeds per plant (318 seeds) than variety S.L 1696 (239 seeds).

The interactive effect of seed size, phosphorus levels and cowpea variety on number of seeds per plant was not significant.

4.2.10 Weight of seed per plant (g)

Neither seed size nor phosphorus applied per hectare had any significant effect on weight of seed produced per plant (Table 4.15). Cowpea variety on the other hand, significantly influenced the weight of seeds produced per plant. Sampea-7 as usual produced heavier seed weight per plant (48.7gm) than S.L 1696 variety (43.41gm).

The interaction between seed size, phosphorus levels and cowpea variety was not significant.

4.2.11 100-seed weight (gm)

Seed size and cowpea variety significantly influenced 100-seed weight (Table 4.15), but not phosphorus levels.

The large seeds produced significantly heavier seeds (18.99 gm/100 seeds) than the medium (18.17gm per 100 seeds) and small (17.45g/100 seeds) seed sizes. The differences among the three classes of seeds were all significant.

Irrespective of the class of seed planted, S.L 1696 variety produced significantly heavier seeds (21.30g/100 seeds) than Sampea-7 variety (15.11g/100 seeds).

Table 4.16: Interactive effect of seed size and cowpea variety on 100 seed weight at Samaru in 1989.

Treatment	Cowpea variety	
	S.L 1696	Sampea-7
Seed size		
Small	19.89a	15.02b
Medium	20.91a	15.43b
Large	23.10a	14.88b
S.E (±)	1.93	

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

The interactive effect of seed size and cowpea variety on 100-seed weight was quite significant (Table 4.16). The implication of this interaction was that, irrespective of the class of seed sown, S.L 1696 variety produced significantly heavier 100-seed weight than Sampea-7 variety, even though the difference among the seed classes for each variety was not significant.

4.3 Correlation Analysis

Correlation coefficients between the different growth characters, yield components and the economic yield were carried out to determine their strength of association or relationship (Table 4.17). There were significant positive correlation between yield and number of flowers per plant; weight of seeds per plant; 100-seed weight; number of seeds per plant; number of pod per plant and plant height at 8 WAP. This character (yield) was however significantly negatively correlated with days to 50% flowering.

There were significant positive correlations between number of flowers per plant and weight of seeds per plant; 100-seed weight; number of seeds per plant; number of pods per plant but negative correlation with number of days to 50% flowering.

Number of leaves per plant (at 8 WAP) was positively and significantly correlated with number of flowers per plant; number of days to 50% flowering; weight of seeds per plant; number of seeds per plant; number of pods per plant and leaf area per plant at 8 WAP. Number of branches per plant was significantly and negatively correlated with number of days to 50% flowering; but positively correlated with weight of seeds per plant; 100-seed weight (all at harvest) and leaf area per plant at 8 WAP.

Table 4.17: Matrix coefficient of correlation (r) between grain yield, yield components and growth of two cowpea varieties (S.L 1696 and Sampea-7) in Samaru in 1989.

	1	2	3	4	5	6	7	8	9	10	11
1.	1										
2.	.94**	1									
3.	-.62**	-.59*	1								
4.	.98**	.97**	-.64**	1							
5.	.45**	.41*	.81**	.46	1						
6.	.91**	.97**	.41*	.93**	-.25	1					
7.	.95**	.99**	-.60**	.97**	-.43*	.97**	1				
8.	.18	.06	.03	.01	.02	.07	.08	1			
9.	.02	.46*	.52*	.41*	.35*	.41*	.48*	.51*	1		
10.	.02	.22	-.69**	.34*	.50*	.07	.22	.32*	.08	1	
11.	.52*	.09	.22	.31*	.14	.06	.09	.17	.07	.17	1

NB: * *Significant at 5%;* ** *Significant at 1% levels of probabilities*

1 = Grain yield (kg/ha)
2 = Number of flowers/plant
3 = Number of days to 50% flowering
4 = Weight of seeds/plant
5 = 100-seeds weight (gm)
6 = Number of seeds/plant.
7 = Number of pod/plant
8 = Leaf area (cm^2) per plant at 8 WAP
9 = Number of leaf per plant at 8 WAP
10 = Number of branches per plant at 8 WAP
11 = Plant height (cm) at 8 WAP

Chapter 5

DISCUSSION

5.1 Effect of Seed Size on:

5.1.1 Growth characters

From the results obtained, large sized seeds had significantly higher germination percnetage than either medium or small seed sizes. Similar behaviour has been reported by Dhillon *et al.* (1976); Haskins (1975); Tseng (1962), Cole-Egharevba (1986) and Sahabi (1988) in alfalfa, rice, groundnut, onion and cowpea respectively. This superiority of large sized seeds over the other grades of seeds used might not be unconnected with higher carbohydrate, total protein and phytin reserves in their cotyledons. Cherry (1963), quantified the dry weight changes in groundnut cotyledons. He observed a 60% depletion of the seed reserves during germination.

Seed size significantly influence stem or vine length, leaf area, number of leaves and shoot dry weight per plant at 4 weeks after planting (WAP) and number of branches per plant at 8 WAP. These steady increases in these characters with increased seed size indicate a more vigorous growth and higher photosynthetic activity at the early growth stage, but this superiority of plants from large seeds decreased as the plants aged. This observation is in conformity with results of Auston and Longden, 1967; Bremner

et al., 1963; Harper and Obeid, 1967; Ezedinma, 1965; Dhillon, 1973 and Smith and Champer, 1975. The results of numerous studies on wheat, barley, herbage legume, alfalfa, sweet clover indicate that large seeds produced plants of more vigorous growth in the intial stages than those from the small seeds (Baniaameur and Caddel, 1976; Black, 1959; Dhillon, 1973; Haskins and Gorz, 1975).

Plants from large seeds become established faster as shown by number of leaves (27), branches (3), and total leaf area (718.97 cm^2) per plant at 4 weeks after planting. Comparable figures when small sized seeds were planted are 22.0, 2.0 and 560.65cm^2 for number of leaves, branches, and total leaf area per plant, respectively. At 8 WAP, values of 149 leaves; 5149.91cm^2 leaf area (small seeds) and 172 leaves; 5009.65cm^2 leaf area (large seed) per plant were recorded. This showed a 28.27% difference between large and small sized seeds at 4 WAP, and 2.79% difference at 8 WAP. The difference between large and small seeds in terms of leaf number was 22.72% and 15.45% at 4 and 8 WAP respectively. This shows that canopy development for large seeds was faster at the early stages of growth than small sized seeds. It therefore follows that when canopy is less than full cover, solar radiation escapes interception by the phtosynthetic apparatus and since dry matter production has a direct relation to the proportion of light intercepted, the large size seeds

will therefore be at an advantage as seen for shoot dry weight and leaf dry weights at 4 weeks after planting. Because of their greater initial "capital" (large embryo and reserves), seedlings from large seeds are almost always heavier, with larger cotyledons and more leaves than those from small seeds (Black, 1956; Lang and Holmes, 1964; Kaufman and Guitard, 1967; Hewston, 1963) and it would be expected that if plant growth followed the compound interest laws (Blackman, 1919), their advantage would persist at least during the early stages only. Black (1956), Lang and Holmes (1964), Scott (1961), Hewston (1963) and Jaggard (1969) have all confirmed this for a wide range of field crops. These authors have all confirmed that in the first 2-4 weeks after emergence, relative growth rates were dependent on seed size. With isolated plants, this advantage in seed size has often persisted throughout the sampling period (Black 1956; Harper and Obeid, 1967) and in field situation interplant competition will develop sooner in populations growing from large seeds. Thus the advantage of using large seed may diminish and crops from large and small seeds may eventually attain similar yields.

5.1.2 Yield and yield components

The insignificant increase in total grain yield, number of pods, number of seeds, seed weight per plant and number of seed per pod with increased seed size

find support from earlier reports by Dhillon *et al.* (1977) in Mungbean; Ezedinma (1965) in cowpea; Ahmed *et al.* (1973) in rape-seed and Adelana (1979) in maize. Since these characters (grain yield, number of pods, number of seeds, seed weight per plant and number of seeds/pod) develop during the late phase of the plant's life, the early advantage of large seed size towards their significant effect on yield was lost (Black, 1956; Hewston, 1963; Dhillon *et al.*, 1977). This result showed that after successful establishment under uniform conditions, final yields of cowpea may not be affected by size of seed at planting (Ezedinma, 1965; Hughes *et al.*, 1957).

5.2 Effect of Levels of Phosphorus Applied for Hectare on:

5.2.1 Growth characters

Number of leaves, vine length, leaf area, shoot-dry weight and leaf dry weight per plant declined as the levels of phosphorus applied per hectare increased. Other characters that followed the same trend included number of pods, number of flowers, seed weight per plant and seed yield per hectare. Even though these were not significant, the lack of response to applied phosphorus could be due to high level of residual phosphorus content of the soils as evidenced from the soil analysis value for the available P (Appendix 1). Available P value of 22.5ppm was more than

sufficient to maintain a good crop of cowpea without a further fertilization with phosphorus. Additional fertilizer probably led to cytological/physiological damage to the crop which must have led to decreased yield obtained from the treated plots. This observation is supported by Bingham (1966) who noted that phosphorus "toxicity" resulted from over fertilization with P-containing fertilizer. He however noted that excessive concentrations of P in the soil may upset Cu^{2+}, Zn^{2+} and Fe^{3+} metabolism in plants. This finding also agrees with Wollny's 1891 Law of diminishing returns - "The yield of crops, as regards quality and quantity, is determined by that factor that, under existing conditions, functions in insufficient minimum or in oversufficient maximum amount or intensity". The implication of this law is that there is always a critical level below which a response to added nutrient may be expected. The critical soil solution (external) P concentration for optimum growth of cowpea in some Nigeria soils have been found to vary between 0.12ppm and 0.53ppm depending on soil type, although the more common value in these soils was about 0.2ppm (Anyaduba and Adepetu, 1982). These authors went further to explain that soils with the least first phase absorption maximum showed the highest P requirement for cowpea growth. Therefore P fertilizer requirement seems to depend on soilP-sorption/desorption characteristics; and it might be difficult to have a

standard solution P concentration value for all tropical soils with regards to cowpea cultivation (Adepetu, 1979).

An evaluation of various works conducted in South-western Nigeria regarding crop response to P-fertilizer application (Osiname, 1974; Sobulo and Osiname, 1981; Obigbesan, 1978 and Adepetu *et al.*, 1979), indicated that application of 15kg P and 30kg P on cowpea for medium and low soil test values respectively was sufficient to maintain optimum growth and yield. This means that quantity of P applied for optimum growth/yield of cowpea has to be varied with soil test values.

5.2.2 Yield and yield components

Grain yield and yield components of cowpea did not respond significantly to applied phosphorus per hectare, instead an insignificant negative response was recorded. Optimum response to applied phosphorus in cowpea occurred at 37.0kg P_2O_5/ha (Anon. 1977). Since the phosphorus content of the soil was more than the critical required for optimum response, no significant positive response in terms of increased yield and yield components could be expected. The slight reduction in yield and yield components with phosphorus level might be due to reduced availability of soil zinc. Langin *et al.* (1962) and Shukla and Morris (1967) observed that application of high amount of phosphorus can lead to reduced zinc concentration in

soybean crop and consequently reduced yields. Rose *et al.* (1982) in a similar experiment with soybean reported increased yield of 23% with 4kg ha^{-1} of zinc. Pauli *et al.* in 1968 observed that weight of plant's part were reduced by varying the proportion of zinc and phosphorus in the soil. Greatest reductions in total dry weight per plant according to Pauli *et al.* (1968), occurred when high P(45%) or high P with low zinc (46%) was applied.

5.3 Effect of Variety on:

5.3.1 Growth characters

Plant height, number of leaves, number of branches, leaf area, leaf dry weight and shoot-dry weight per plant were all significantly influenced by cowpea variety. The significant effect of variety on these growth characters could be due to genetic control exercised over these variables which sometimes may be modified by the environment (Anon., 1985). The improved local S.L 1696 variety had longer vines, more number of leaves, leaf area and shoot-dry weight per plant than Sampea-7 variety. The number of branches per plant was however higher for Sampea-7 than S.L 1696 variety. This might be due to the fact that Sampea-7 variety was bred for higher yield, and number of branches developed per plant is a strong yield determinant (A.A. Zaria Personal Communication).

5.3.2 Yield and yield components

The results obtained in this study revealed that, cowpea grain yield was highly dependent on the variety planted. Sampea-7 had higher grain yield than S.L 1696 variety. This might not be unconnected with the higher number of branches, number of pods, number of seeds, and weight of seeds/plant recorded for Sampea-7 variety. Weight of 100-seed for S.L 1696 was however significantly higher than Sampea-7 (21.30 and 15.11g/100 seeds of S.L 1696 and Sampea-7 respectively). These findings are in conformity with those of Sahabi (1988) who reported that SVU-48 (now Sampea-7) had significantly lower 100-seed weight than local Kanannado variety.

5.4 Effect of Interactions

Significant seed size and cowpea variety interactions were observed on number of leaves at 4 WAP, branches at 8 and 10 WAP and 100-seed weight at harvest. Improved local variety (S.L 1696) irrespective of seed size, produced significantly more leaves (at harvest), than improved Sampea-7 variety. This shows the dominance of the improved local variety over Sampea-7 in terms of vegetative growth. Variety S.L 1696 being an improved local crop was more adapted to the local conditions than the Sampea-7 variety. It was also observed, that if the influence of variety was kept constant, large sized seeds had higher number of

leaves, leaf area, shoot dry weight, and longer vines than small sized seeds. Reports by Sahabi (1988) also confirmed this finding. This may be due to larger food reserves in large seeds compared to the small ones.

The interaction between the levels of phosphorus applied per hectare and cowpea variety, significantly influenced the vine length (at 4 WAP); number of days to 50% flowering and threshing percent (at harvest). Improved local S.L 1696 variety produced longer vines at both the control and 37.5kg P per hectare plots than Sampea-7, while at 75.0kg P ha^{-1}, the vine length was statistically similar to those produced by all the plots of Sampea-7 at 4 WAP. This indicates that the S.L 1696 variety was more susceptible to the 'toxic' effect of the high phosphorus levels than Sampea-7.

Levels of phosphorus had no effect on the number of days to 50% flowering for S.L 1696 variety, while P- levels significantly influenced the number of days to first flowering for Sampea-7.

Improved local S.L 1696 variety took longer days to attain 50% flowering and had higher threshing % than Sampea-7 at all levels of P-fertilizer. Variety S.L 1696 is photo-period sensitive. This observation agrees with Steele (1972) who concluded that Nigerian short-day cultivars are physiologically adapted to flowering at the

end of the rains. Control plots of Sampea-7 variety took an average of 50 days to reach 50% flowering while treated plots took 53 days.

The interaction of seed size and cowpea variety on 100-seed weight was significant, indicating that S.L 1696 variety produced heavier seeds than Sampea-7. The smallest seeds of S.L 1696 weighed 19.89 g/100-seeds while the largest seeds of Sampea-7 weighed 15.88g/100-seeds.

5.5 Correlation

The significant and positive association between grain yield and plant height observed may probably be due to the fact that increased plant height exposed the plants to greater solar radiation for photosynthesis (Sahabi, 1988). This was further confirmed by the positive correlations of plant height to number of leaves, and leaf area per plant, all of which are important determinants of photosynthetic rate and hence high grain yield. This agrees with findings of Black (1956) in subterranean clover and Fehr and Probst (1971) in soybeans who reported positive correlations between grain yield and leaf area and plant height. A highly positive correlation between plant height and grain yield of cowpea have also been reported by Singh *et al.* (1982).

The highly significant and positive correlation between number of flowers; number of pods; number of seeds per plant; weight of seeds per plant and 100-seed weight with

grain yield revealed these to be important components and determinants of grain yield of cowpea. The results are similar to the findings of previous workers (Singh *et al.*, 1982; Tenebe, 1987; and Sahabi, 1988) in which number of seeds per plant and 100-seed weight were found to be important yield components of cowpea. Chiezey (1989) in a similar study with soybean observed that the number of pods per plant and 100-seed weight were the two most important yield components.

Chapter 6

SUMMARY AND CONCLUSION

A field trial was conducted at the Institute for Agricultural Research farm (Horticultural garden) in Samaru during the 1989 wet season to investigate the effect of seed size and phosphorus levels on the yield and yield components of two cowpea varieties (*Vigna unguiculata* [L.] Walp) varieties.

The treatments consisted of two varieties (S.L 1696 and Sampea-7), three seed sizes (large, medium and small) and three phosphorus levels (0, 37.5 and 75.0kg P_2O_5/ha). These were randomly combined and laid out in split-plot design with three replications.

Large sized seeds had significantly higher percent germination at 6 days after planting and number of leaves; leaf area; shoot dry weight and leaf dry weight per plant at 4 weeks after planting. Number of branches per plant was however significantly influenced by seed size at 8 WAP. Large sized seeds produced higher number of flowers, pods, seeds per plant, weight of seeds per plant, number of seeds per pod and grain yield than small sized seeds, but the difference was not significant except for 100-seed weight.

Total leaf area, number of leaves, shoot dry weight per plant, yield and yield components decreased progressively with increasing levels of phosphorus. This decrease was however not significant. Crude protein percent however increased significantly with increasing phosphorus level.

Varietal effects on the growth and yield of cowpea were highly significant. Variety S.L 1696 was more vigorous in vegetative growth than Sampea-7. It produced higher number of leaves, leaf area, leaf dry weight, and heavier seeds than Sampea-7 variety. Sampea-7 however exceeded S.L 1696 in number of branches, pods produced, seed weight and pod weight per plant. It also significantly out-yielded the S.L 1696 variety by 65% in grains.

Interactive effects of seed size and cowpea variety significantly influenced vine length, number of leaves, leaf area and shoot dry weight/plant. Variety S.L 1696 was significantly taller, had higher number of leaves, leaf area, and shoot dry weight per plant than Sampea-7. Interactive effects of seed size and cowpea variety significantly influenced number of branches at 8 and 10 WAP and 100-seed weight at harvest. Variety S.L 1696 had significantly more leaves, higher 100-seed weight than Sampea-7. Large sized seeds of Sampea-7 significantly produced higher number of branches than any of the other seed sizes of S.L 1696 variety.

The interaction, between the levels of phosphorus used and cowpea variety significantly influenced vine length at 4 WAP, threshing percent and number of days to 50% flowering. Variety S.L 1696 except at 75.0kg P_2O_5/ha level, produced significantly longer vines than Sampea-7 which showed significantly lower threshing percentage, all other plots showed similar threshing percentage for the two varieties.

The correlation between grain yield and yield components (number of flowers, pods, seeds and weight of seeds/plant) and vegetative growth characters (stem length, number of leaves and leaf area) were highly significant and positive.

From the above findings conclusions can be drawn as follows:

(i) Using large seeds usually result in increased emergence percentages and speedier growth. Because of their greater embryo size, reserves and early photosynthesis, large seeds produced larger seedlings and the advantage may persist to increase final yield, particularly for short growing season crops. Increases in yield are most likely to be obtained where specific yield components are determined during early growth.

(ii) Where soil test results indicate high P levels, there may be no need to add P-fertilizer.

(iii) Where the economic yield (grain) of cowpea is the goal, Sampea-7 variety could serve as a better choice (assuming other things remain the same) than variety S.L 1696.

REFERENCES

Adelana, B.O. (1979). A note on the effect of seed size on the growth of two varieties of maize. Ife Journal of Agriculture, 1 (2) 172-182 pp.

Adepetu, J.A. (1878). Root growth and nutrient flux of cowpea under field conditions. Ife Journal of Agriculture 1 (1): 7-16.

Agboola, A.A. and G.O. Obigbesan (1977). 'Effects of different sources and levels of P on the performance and uptake of Ife-Brown variety of cowpea'. Ghana Journal of Agric. Sci. 10(1): 71-75.

Ahmed, S.U. and M.I. Zuberi (1973). Effects of seed size on yield and some of its components in rape-seed (*Brassica campestris* L. var. Toria). Crop Sci. 13: 119-120.

Alam, Z. and S. Locascio (1965). Effect of seed size and depth of planting brocooli and beans. Proc. of Florid State Hort. Soc. 78: 107-112.

Allison, L.E. (1965). Organic Carbon. In: Black, C.A. (ed.) Methods of Soil Analysis Part 2. Chemical and Microbiological Properties. American Society of Agron. Madison, Wisconsin, U.S.A., 1376-1378 pp.

Anonymous (1966). Statistical year book; Northern Nigeria, Ministry of Economic Planning, Kaduna, 2-11 pp.

Anonymous (1975). Offical methods of analysis of the A.O.A.C. Association of official Analytical Chemists. 12th ed., Washington, D.C., 483 p.

Anonymous (1977). Notes on the cowpea and grain legume. Cropping Scheme Meeting, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria, 20 pp.

Anonymous (1979). Notes on the Cowpea and Grain Legumes Research Programme. Cropping Scheme Meeting, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria, 26 pp.

Anonymous (1985). 'Sole Crop Cowpea Production Package for the Savannas'. Legumes and Oilseeds Research Programme, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria, 13 pp.

Anyaduba, E.T. and J.A. Adepetu (1982). Predicting phosphorus fertilization need of tropical soils; significance of the relationship between critical solution P requirement of cowpea phosphorus sorption potential and free iron content of soil. Journal of Tropical Agriculture and Veterinary Sciences 21 (1): 21-30 pp.

Auston, R.B. and C. P. Longden (1967). Some effects of seed soze and maturity on yield of carrot crop. Journal Hort. Sci 42: 339-353.

Baniaameur, L. and J.I. Caddel (1976). Barley kernel size in relation to seedling vigour, yield and yield components. Agronomy Abstract, 92 p.

Bank, L.W. (1983). Effect of timing foliar zinc fertilizer on yield components of soybean. Soils and fertilizers Abstract 46 (2) 212 p.

Bingham, F.T. (1966). Phosphorus In: H.D. Chapmand (ed.) Diagnostic Criteria for Plants and Soils. Division of Agricultural Science, University of California, Berkeley, 324-361 pp.

Black, J.N. (1956). The influence of seed size and depth of sowing on pre-emergence and early vegetative growth of subterranean clover (*Trifolium subterraneum L.*). Australian Journal of Agricultural Research 1: 97-109.

Black, J.N. (1959). Seed size in herbage legumes. Herbage Abstract. 29: 235-241.

Blackman, V.H. (1919). The compound unterest Law and plant Growth. Annals of Botany, London: 33: 353-360.

Bola, O.A.O. (1974). The role of legumes and garden crops in meeting our nutritional requirements. Proceedings of the Agricultural society of Nigeria, 2: 41-42 pp.

Borovice, D.S. (1965). The productive capacity of wheat seed and spike of different size. Field Crop Abstract 18: 582.

Boulter, D.; I.M. Evans; a. Thompson and A. Yarwood (1975). The Amino acid composition of *Vigna unguiculata* meal in relation to nutrition. In: Milner, M. (ed.) Proceedings of a symposium on Nutritional Improvement of Food Legumes by Breeding, New York NY, United Nations Protein Advisory Group.

Bremner, P.M.E. and R.K. Scoth (1963). The relative importance of embryo size and endosperm size in causing the effects associated with seed size in Wheat. Journal of Agricultural Science 61: 139-145.

Bremner, J.M. (1965). Total nitrogen. In: Black, C. A. (ed.) Methods of Soil Analysis. Agronomy Monograph 9: 1324-1341. American Society of Agronomy, Madison, Wisconsin.

Brenchley, W.E. (1923). Effect of weight of seed upon the resulting crop. Annals of Applied Biology 10: 223-229.

Bressani, R.; and L. G. Elias (1979). The nutritional role of polyphenols in beans. In: I D R C (International Development Research Centre), Polyphenols in Cereals and Legumes, Ottawa, Canada, 145 pp.

Burkhill, I.H. (1953). Habits of man and the origins of the cultivated plants of the old world. Proceeding of the Linnean Society, London 64: 12-42.

Burris, J.S.; A.H. Wahab and O.T. Edje (1971). Effects of seed size on seedling performance in soybeans. I. Seedling growth and respiration in the dark. Crop Science 11: 492-496.

Burris, J.S.; A.H. Wahab and O.T. Edje (1973). Effects of seed size on seedling performance in soybeans. II. Seedling Growth and Photosynthesis and Field Performance. Crop Science 13: 207-210.

Carleton, A.E. and Cooper, C.S. (1972). Seed size effects upon seedling vigour of three forage legumes. Crop Science 12: 183-186.

Caswell, G.H. (1968). The storage of cowpea in the Northern states of Nigeria. Proceedings of Agricultural Society of Nigeria 5: 4-6.

Cherry, J.H. (1963). Nucleic acid, mitochondria and enzyme changes in cotyledons of peanuts seeds during germination. Plant Physiology 38: 440-443.

Chiezey, U.F. (1989). Effect of plant density and phosphorus fertilizer on the yield and yield components of soybean (*Glycine max L.*) Merrill. Unpublished Agronomy Seminar, Ahmadu Bello University, Zaria, Nigeria, 33 pp.

Clark, B.E. and N.H. Peck (1968). Relationship between the size and performance of snap bean seeds. New York Agricultural Experimentation Bulletin 819 pp.

Cole-Egbarevba, R.K.A (1986). The effect of seed size and storage conditions on the germination and yield of onions (*Allium cepa L.*). A Thesis submitted to the Faculty of Agriculture in Partial fulfilment for a Ph.D Degree, 118 pp.

Day, P.L. (1965). Particle fractionation and particle size analysis In: Black, C.A. (ed.). Methods of soils analysis, Part 1. Physical and mineralogical properties, American Society of Agronomy, Madison, Wisconsin, U.S.A. 545-567 pp.

Deshapande, A.M. and Bathkal, B.G. (1965). Effect of phosphorus on Mungbean (*phaseolus aureus*). Indian Journal of Agronomy 10 (3): 271-278 pp.

Dhillon, G.S. (1973). Effect of seed size on the growth, yield and composition of soybean (*Glycine max* [L.] merril). Ph.D Thesis In: 'Crop production in relation to seed size'. Seed Research 4 (2): 143-155.

Dhillon, G.S.; D.S. Kler and A.S. Walia (1976a). Effect of seed vigour of groundnut and some pulse crops on the seedling establishment. International Symposium Abstract, P.A.U. Ludhiana, 89-90 pp.

Dhillon, G.S.; D.S. Kler and A.S. Walia (1976b). Effect of picking date, *Rhizobium* culture and size of the seed used on the germinability and protein content of the *phaseolus aureus* seed produced. International Symposium Abstract P.A.U., Ludhiana, 101-102 pp.

Dhillon, G.S. and D.S. Kler (1976). Crop production in relation to seed size. Seed Research (2): 143-155 pp.

Dhillon, G.S.; D.S. Kler and A.S. Walia (1977). Effect of seed size on the growth, yield and quality of Moong Bean (*Vigna aureus* var. ML-1). Seed Research 5 (1): 37-43 pp.

Duncan, D.B. (1955). Multiple range and multiple F-test. Biometrics 11: 1-42.

Edje, O.T. and J.S. Burris (1971). Effects of soybean seed vigour on field performance. Agronomy Journal 63: 536-538 pp.

Edward, C.J. Jr. and E.E. Hartwig (1971). The effect of seed size upon rate of germination in soybean. Agronomy Journal 63 (3): 429-430 pp.

Elias, L.G.; R. Colindres and R. Bressani (1964). The nutritive value of eight varieties of cowpea (*Vigna sinensis*). Journal of Food Science 29: 118-122 pp.

Erickson, L.C. (1946). The effect of alfalfa seed size and depth of seedling upon the subsequent procurement of stand. Journal of American Society of Agronomy 39 (10): 964 p.

Ezedinma, F.O.C. (1965). The influence of seed size and fertilizer on the development and yield of cowpea (*Vigna sinensis* Endl.). The Nigerian Agricultural Journal 2 (2): 75-79 pp.

Faris, D.G. (1965). The origin and evaluation of the cultivated forms of *vigna sinesis*. Canadian Journal of Genetics and Cytology 7, 433-452.

Fehr, W.R. and Probst, A.H (1971). Effect of seed source on soybeans strains performance for two successive generations. Crop Science 11: 865-867 pp.

Foxtes, L.A.N. and A.J. Ohlrogge (1972). Influence of seed size and population on yield and other characteristics of soybean (*Glycine max.* [L.] *Merill*). Agronomy Journal 64: 833-836 pp.

Garg, K.P.; A.K. Sharma and B.T. Thakur (1970). Manuring cowpea. I. Studies on the effects of different rates of phosphorus and molybdenum on the growth, yield of cowpea and fodder and residual effect on wheat. Indian Journal of Agronomy 15: 112-117 pp.

Gills, A.S.; R.K. Pandey M. Singh and C.T. Abichandari (1971). Effect of soil anf foliar application of phosphorus on seed yield of cowpea (*Vigna sinensis*). Indian Journal of Agronomy 16 93: 303-304 pp.

Harris, S. and S.S. Gill (1981). Effect of seed size and sowing dates on seed crop of pea. Seed Research 9 (2): 122-125 pp.

Hartwig, E.E. and C.J. Edward Jr. (1970). Effects of morphological characteristics upon seed yield in soybeans. Agronomy Journal 62: 64-65 pp.

Harper, L.J. and M. Obeid (1967). Influence of seed size and depth of sowing on the establishment and growth of varieties of fibre and oil seed flax. Crop Science 7: 527-532 pp.

Haskins, F.A. and H.J. Gorz (1975). Influence of seed size, planting depth and companion crop on emergence and vigour of seedlings in set clover. Agronomy Journal 67: 652-666 pp.

Hewston, L.J. (1963). Effects of seed size on germination, emergence and yield of some vegetable crops. M.Sc. thesis, University of Brimingham, United Kingdom. In: Seed Science and Technology (1977) 5: 337-352 pp.

Hughes, H.D.; E.R. Henson; D.S. Metcalfe and L.J. Johnson (1957). 'Crop Production'. Principles and Practices. The Macmillan Company, New York, 35-37 pp.

Hutton, E.M. (1970). 'Tropical Pastures'. Advances in Agronomy 22: 1 - 73 pp.

Jaggard, K.W. (1969). Some effects of seed size upon the growth of sugar beet crop. B.Sc. Dissertation, University of Nottingham, U.K. In: Seed Science and Technology, 1977 (5): 343 p.

Jarayam, R. and S. Raminah (1980). 'Effects of phosphorus and growth regulators on flower shedding of cowpea'. Madras Agricultural Journal 67 (3): 183-186. In: Cowpeas: Abstracts of World Literature, IV: 59 p.

Johnson, D.R. and V.D. Lendders (1974). Effect of planted seed size on the emergence and yield of soybeans (*Glycine max* (L.) *Merril*). Journal of Agronomy 66: 117-118 pp.

Johnson, W.A. and C.E. Evans (1975). 'Nitrogen, phosphorus and potassium fertilization of southern peas for one-time harvest on sandy soil: Journal of the American Society of Horticultural Science 100 (3): 261-263.

Kang, B.T. and D. Nangju (1983). 'Phosphorus response of cowpea (*Vigna unguiculata* [L.] *Walp*)'. Tropical Grain Legume Bulletin, 27: 11-16 pp.

Kaufman, M.L. and A.D. McFadden (1960). The competitive interaction between barley plants grown from large and small seeds. Canadian Journal of Plant Science 4: 623-629 pp.

Kaufman, M.L. and A.A. Guitard (1967). The effect of seed size on early plant development in barley. Canadian Journal of Plant Science 47: 73-78 pp.

Kerya, S.O. (1977). Nodulation and nitrogen fixation in legume in East Africa. In: A. Ayanaba and P.J. Dart (eds.). Biological nitrogen fixation in farming systems of the tropics. John Wiley and Sons, New York, 233-243 pp.

Kidd, F. and C. West (1918). A quantitative analysis of plant growth. Annals of Applied Biology 7, 103-123 pp.

Kiesselbach, T.A. (1924). Relation of seed size to the yield of small grain crops. Journal of American Society of Agronomy 16: 670-681 pp.

Kneeborne, W.R. and C. L. Gremer (1955). The relationship of seed size to seedling vigour in some native grass species. Agronomy Journal 47 (10): 472 pp.

Kunju, U.M.; N. Sadananda; V.R. Nair and P.M. Nair (1976). Performance of cowpea varieties under varying levels of phosphorus in red-loam soils' Agricultural Research Journal of Kerala 14 (2): 180-181 pp.

Kurdikeri, C.B.; R.V. Petil and K. Krishnamurthy (1973). Response of cowpea varieties under varying levels of P. Mysore Journal of Agriculture 7(2): 170-177. In: Cowpeas Abstracts of World Literature 1: 142 p.

Kurup, K.R. and R. Kaliappan (1966). The influence of phosphorus fertilization on legumes. The Madras Agricultural Journal 56 (1): 13-14 pp.

Lang, R.W. and J.C. Holmes (1964). The growth of the Swede crop in relation to seed size. Journal of Agricultural Science Camb. 63: 221-227 pp.

Langin, E.J.; R.C. Ward, R.A. Olsen and P.F. Roades (1962). Factors responsible for poor response of corn and grain sorghum to phosphorus fertilization II. Lime and P placement effect on P-Zn relations. Soils Sci. Soc. Ameri. Proc. 26: 514-578.

Laskar, S. and K.S. Dadwal (1981). Cowpea responds to zinc and Molybdenum in Tripura. Indian Farming 31(3): 10-11 pp.

Loomis, R.S and W.A. Williams (1963). Maximum crop productivity. An estimate. Crop Science 3: 67-72 pp.

Lush, W.M. and L.T. Evans (1981). The emergence of grass and legumes seedlings planted at different depths in fine soil types. Journal of American Society of Agronomy 31: 17-23 pp.

Nangju, D. and S.B.C. Wanki (1979). Estimating leaf area of cowpea and soybeans using dry weight of terminal leaflets. Experimental Agriculture 16: 149-151 pp.

Obigbesan, G.O. (1978). Nutritional problems in root crop production in a tropical country-Nigeria. 'Beitrage Zur Tropischen'. Veterinary Medicale 78 (3): 289-298 pp.

Okelana, M.A.U. and N.O. Adedipe (1981). Effect of phosphorus nutrition on growth, fruit abscission and seed yield of cowpea (*Vigna unguiculata*) 2. Pflanzenernachr, Bodenkd, 144(b) 546-556. In: Cowpea: Abstracts of World Literature, IV: 60p.

Oliveria, J.P.; J. Kluthcouski and H. Aidar (1982). Effects of phosphorus levels, cultivar and plant population on cowpea (*Vigna unguiculata*) production. Tropical Grain Legume Bulletin, 25: 15-17 pp.

Olsen, S.R.; C.V. Cole; F.S. Watanabe and L.A. Dean (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular, 939.

Omueti, J.A. and V.A. Oyenuga (1970). Effects of phosphorus fertilizer on the protein and essential components of the ash of groundnuts and cowpea: West African Journal of Biological and Applied Chemistry 13 (1): 14-19 pp.

Oexeman, S.W. (1942). Relation of seed weight to negative growth, differentiation and yield in plants. American Journal of Botany 29: 72-78 pp.

Pandy, R.M. (1968). Change in nitrogenous fractions of certain crop plants as affected by phosphorus deficiency. Flora (Jena) (A) 159(4) 299-306 In: Cowpeas: Abstracts of World Literature 1: 145 p (195-1973).

Pauli, A.W.; Elias Roscoe Jr. and H.C. Moser (1968). Zinc uptake and translocation as influenced by phosphorus and calcium carbonate. Agronomy Journal 60: 394-396.

Piper, C.V. (1913). The wild prototype of cowpea. In: Cowpea (ed.): Research, Production and Utilization. John Wiley and Sons, 2-23 pp.

Pratt, P.F. (1965a). Potassium. In: C.A. (ed). Methods of Soil Analysis Part 2. Chemical and Microbiological Properties. American Society of Agronomy, Madison, Wisconsin, U.S.A. 1022-1030 pp.

Pratt, P.F. (1965b). Sodium In: Black, C.A. (ed.). Methods of Soil analysis Part 2. Chemical and Microbiological Properties. American Society of Agronomy, Madison, Wisconsin, U.S.A., 1031-1034 pp.

Purseglove, J.W. (1976). The orings and migration of crops in tropical Africa. In: Harlan, J.R. (ed.). Origins of African Plant Domestication, The Hague, Mouton Press. 291-309 pp.

Rachie, K.O. and Roberts, L.M (1974). Grain Legumes of the Lowland Tropics. Advances in Agronomy 26, 44-61 pp.

Randhawa, A.S.; S.C. Anand and S. Ranjit (1969). Annual report of plant breeding Department for the year 1968-69, Punjab Agricultural University, Ludhiana.

Randhawa, G.S. (1972). Agronomic investigations with seed size of 'wheat-kalyan sona'. Ph.D Thesis In: Crop Production in Relation to Seed Size (1976). In: Seed Research 4(2): 143-155.

Rawal, K.M. (1975). National hybridization among wild, weedy and cultivated *Vigna unguiculata* [L.] Walp). Euphytica 24: 699-707.

Rhodes, E.R. (1980). Use of phosphate sorption Isotherms to predict the P-equirement of cowpea. Tropical Grain Legumes Bulletin 21: 10-21 pp.

Rhodes, E.R. (1981). The economics of fertilizing cowpea (*Vigna unguiculata*), with basic slag, oxisol in Njala and the effects of the fertilizer on leaf lamina N,P, Zn-contents and nodulation. Tropical Grain Legumes Bulletin 22: 6-10 pp.

*

Rose, I.A.; W.L. Felton and L.W. Bank (1982). Response of four soybeans to foliar zinc fertilizer. Soils and fertilizers Abstract 45(1) 1069 p.

Sahabi, B.A. (1988). The effects of seed size and number of seeds per hole on the growth and yield of cowpea (*Vigna unguiculata* [L.] Walp) varieties. Unpublished M.Sc. Thesis, Ahmadu Bello University, Zaria, Nigeria, 55-66 pp.

*Rogler, R.A. (1954). *Seed size and seedling vigour in creasted wheat grass.* Agronomy Journal 46: 216 p.

Schmidt, D.A. (1922). Study of plant growth in relation to weight of seed. Netherland Journal of Agricultural Experimentation Station, 3rd Annual Report, 388-394 pp.

Scott, R.K. (1961). 'The significance of seed size and associated factors in the early growth of Winter Wheat'. B.Sc. Dissertation, University of Nottingham, U.K. In: Seed Science and Technology 1977, 5: 339 p.

Shukla, U.C. and H.D Morris (1967). Relative efficiency of several zinc sources for corn (Zea mays L.) Agronomy Journal 59: 200-202 pp.

Singh, R.M. and Jain, T.C (1966). Effect of phosphate and molybdate on the growth characters of Russian giant cowpea (*Vigna sinensis*). Allahabad Farmer 46(1): 29-32 In: Cowpea: Abstract of World Literature 1: 46.

Singh, J.N.; S.K. Tripathi and P.S. Neji (1972). Note on the effect of seed size on germination, growth and yield on soybean (*Glycine max.* [L.] *Merr.*) Indian Journal of Agricultural Science 67: 681-685 pp.

Singh, R.; B.S. Joshi and S. Singh (1982). Correlation studies in cowpea. Tropical Grain Legumes Bulletin 26: 3-5 pp.

Smith, T.J. and H.M. Camper (1970). Effect of seed size on soybean performance. Agronomy Abstracts. 67p.

Smith, T.J. and H.M. Camper (1975). Effect of seed size on soybean performance. Agronomy Journal 67: 681-685 pp.

Snedecor, G.W. and W.G. Cochron (1967). Statistical methods 6th (ed.). Iowa State University Press, Ames, Iowa, USA.

Sobulo, R.A. and O.A. Osiname (1981). Soils and fertilizer use in Western Nigeria. Research Bulletin, Institute for Agricultural Research and Training, University of Ife, Ile-Ife, Nigeria (11): 8-17 pp.

Steele, W.M. (1972). 'Cowpeas in Nigeria'. A thesis for the degree of Doctor of Philosophy, submitted to the Department of Agricultural Botany, University of Reading 87-88 pp.

Steele, W.M. (1976). Cowpeas (*Vigna unguiculata*). In: Simmonds, N.W. (ed.). Evolution of Crop Plants, London, U.K. Longmans, 183-185 p.

Steele, W.M. and K.L. Mehra (1980). Structure, evolution and adaptation to Farming System and Environment in *Vigna*. In: Summerfield, R.J. and A.H. Bunting (eds.). Advances in Legume Science, 393-404 pp.

Summerfield, R.J.; P.A. Huxley and W.M. Steele (1974). Cowpea (*Vigna unguiculata* [L.] *Walp*). Field Crop Abstract 27: 301-312 pp.

Tandon, J.P. and S.C. Gulati (1968). Influence of non-genetic variation in seed size on qualitative characters in Barley. Indian Journal of Genetic Plant Breeding 26 (2): 162-169.

Tarila, M. and D. Sene (1966). Lehanicot nieve (*Vigna unguiculata* [L.] *Walp*) and Senegal L' Agronomy Tropicale 8: 918-925 pp.

Tarila, A.G.I.; D.P. Ormond and N.C. Adedipe (1977). Effect of phosphorus nutrition and light intensity on growth and yield development of cowpea (*Vigna unguiculata* [L.] *Walp*). Annals of Botany, 41: 75-83 pp.

Tawain, G.P. (1965). Effects of nitrogen, phosphorus and potassium on nodulation of cowpea. Experimental Agriculture 1: 257-259.

Tawee, P. (1972). Relationship of seed size and planting rate to field performance in soybeans. Thesis for the Degree of Master of Science, Miss. State University, State College, Miss.

Tenebe, V.A. (1987). Effect of sources of phosphorus on the yield and yield components of cowpea (*Vigna unguiculata* [L.] *Walp*) varieties . Unpublished M.Sc. Thesis, Ahmadu Bello University, Zaria, Nigeria: 46-57 pp.

Terman, G. L. (1971). Phosphate fertilizer sources agronomy effectiveness in relation to chemical and physical properties. The fertilizer society of London Proceedings. No. 123: 39 pp.

Townsend, C.E. (1972). Influence of seed size and depth of planting on seedling emergence of two milk vetch species. Agronomy Journal 64: 627-630 pp.

Tseng, S.T. and C.I. Indn (1962). Studies on the physiological quality of pure rice seed. Proceeding of International Seed Test Association 27 (2): 459-475. In: Field Crop Abstract 16 (2): 687-1663 pp.

Twamley, B.E. (1974). Recurrent selection for seedling vigour on birds foot trefoil. Crop Science 14: 87-90 pp.

Vavilov, N.I. (1951). The origin, variation, immunity and breeding of cultivated plant. Chronica Botanica 13: (1949 - 1930), 1-364 pp.

Waldron, L.R. (1941). Analysis of yield of hand-red spring wheat, grown from seed of different weights and origin. Journal of Agricultural Research 62: 445-460 pp.

Whitney, A.S. (1975). Contribution of forage legumes to the nitrogen economy of mixed swards. A review of relevant Hawaiian Research pp. 89-96 In: Ayanaba, A. and P.J. Dart (eds.). Biological nitrogen fixation in farming systems of the tropics, Johnwiley & Sons. New York.

Williams, R.F. (1948). The effects of P-supply on rates of intake of P and nitrogen and upon certain aspects of P metabolism in gramineous plants. Australian Journal of Agricultural Research 31: 333-361 pp.

Wollny, E. (1891). 'Die Kultur der Getrie darten mit Rucksicht auf und wissen chaft. Winter Heidelberg, 67 pp. In: Gaunch, H.G. (ed.). Inorganic Plant Nutrition, Dowden, Hutchinson and Ross Inc. 130 pp.

Wood, D.W.; P.C. Longden and R.K. Scott (1977). Seed size variation; its extent, source and significance in field crops. Seed Science and Technology 5: 337-352 pp.

Yayock, J.Y. (1975). 'Cowpeas and soil fertility'. In: Notes on cowpea and grain legume improvement programme, Cropping Scheme Meeting, Institute for Agricultural Research, Ahmadu Bello University, Zaria, 15 pp.

Yusuf, Y. (1987). 'Effects of P-levels on yield and yield components of cowpea at Samaru' In: Cowpea sub-programme, Legume and Oil seeds Research Programme, Cropping Scheme Meeting, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria, 161 pp.

APPENDIX 1

PHYSICAL AND CHEMICAL PROPERTIES OF THE SOIL OF THE EXPERIMENTAL PLOTS IN SAMARU

Physical Composition (%) (0 - 30cm depth)	
Clay	20
Silt	40
Sand	40
Textural class	Loam
Chemical Composition	
pH (H_2O) (1 : 2.5)	5.20
pH (in 0.01M $CaCl_2$) (1 : 2.5)	4.10
Org. carbon (%)	0.42
Available P (ppm)	22.5
Total N (%)	0.049
Exchangeable bases (Meq/100g Soil)	
Ca	1.41
Mg	0.50
K	0.14
Na	0.05
C.E.C.	3.20
Sesquioxide	
Al + H	0.40 meq/100g. Soil

APPENDIX 2

TOTAL RAINFALL, MAXIMUM AND MINIMUM TEMPERATURE, RELATIVE HUMIDITY AND SUNSHINE HOURS AT TEN DAY INTERVALS DURING THE PERIOD OF THE PERIOD OF THE EXPERIMENT AT SAMARU IN 1989

Month	Days	Total rainfall (mm)	Maximum Temperature °C	Minimum Temperature °C	Relative humidity (%) a.m	p.m	Sun shine (hours)
	1-10	55.4	31.9	20.8	70.6	55.2	7.84
June	11-20	21.0	31.0	20.5	69.0	54.0	8.52
	21-30	48.0	28.4	18.7	70.8	64.9	6.07
	1-10	26.9	30.0	20.0	74.0	63.0	7.95
July	11-20	31.5	28.9	19.4	80.9	59.5	6.35
	21-31	101.3	29.4	19.7	81.9	66.6	5.76
	1-10	55.1	27.4	19.5	82.4	76.6	4.27
August	11-20	28.9	28.0	19.4	81.3	69.7	6.45
	21-31	85.5	28.5	19.1	81.4	67.0	6.62
	1-10	78.7	28.6	19.1	81.7	70.6	5.31
Sept.	11-20	29.9	30.1	19.2	77.8	65.3	6.91
	21-30	9.7	30.7	19.3	75.6	64.7	7.10
	1-10	51.9	30.0	19.3	74.9	63.5	7.51
October	11-20	I.0	30.7	17.8	61.7	43.2	8.11
	21-31	Nil	31.2	12.7	22.1	22.4	9.69

Source: IAR Meteorological Station, Samaru.