INFLUENCE OF PHOSPHORUS AND SEED SIZE ON GROWTH, YIELD AND YIELD COMPONENTS OF TWO SOYBEAN *(Gtycute max.* L., Merrill) VARIETIES

BY

NDAKO SOOLAYMANN MAJIN

A Thesis submitted to the Postgraduate School, Ahmadu
Bello University, Zaria, in Partial fulfillment of the requirements
for the Degree of Master of Science in Agronomy

DEPARTMENT OF AGRONOMY
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY
ZARIA, NIGERIA.

DECEMBER, 1994.

DECLARATION

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

N. S. Majin

(candidate)

Date: 10.12.95

The above declaration is confirmed.

Dr. Y. Yusuf.

(Major supervisor)

Date: 22/12/95

CERTIFICATION

This thesis is entitled ' INFLUENCE OF PHOSPHORUS AND SEED SIZE ON GROWTH, YIELD AND YIELD COMPONENTS OF TWO SOYBEAN VARIETIES' by N.S. Majin meets the regulation governing the award of the degree of Master of Science of Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

Dr. Y. Yusuf
Chairman, Supervisory
Committee

Dr. O. O. Olufajo
Member, Supervisory
Committee

Dr. W. B. Ndahi
Member, Supervisory
Committee.

Prof. S. T. O. Lagoke
Head,
Dept. of Agronomy

Dean,
Postgraduate School,
Ahmadu Bello University
Zaria.

Date: 30/7/96

DEDICATION

This piece of work is entirely dedicated to the following:

- My parents; the persons of ALHAJ SOOLAYMANN MAJIN and NANA FATEEMAH MAJIN
- My wife and children, viz. ASABE, N. MAJIN JR. , NANA FATEEH and N- MUSTAPHA MOHAMMAD.
- All my good BROTHERS and SISTERS.

Acknowledgement

All thanks and praises be to the Almighty ALLAH for giving me the life, health, strength and courage to under take this research project and the entire postgraduate programme successfully.

Special gratitude and thanks are to my major supervisor, Dr. Y. Yusuf, forma ly the Head of Department of Agronomy, for his scholarstic encouragement and father-like attension during this M.Sc. course particularly the success of this reseach. Iam also very grateful to the present Head of Department of Agronomy i.e. Prof. S.T.O. Lagoke, for his persistent concern for a timely complition of this p roject.

My appreciation goes to Dr. O.O. Olufajo (a member of my supervisory committee) through whom the seeds of the two cultivars used for this project were obtained and also for his useful directives and guidance throughout this research work.

I appreciate the initial help accorded me by Dr. I.O.E. Asenime (a former member of my supervisory committee) who, unfortunately could not witness the end of this project due to his untimely death. May his soul rest in peace.

Many thanks to Dr. W.B. Ndahi (a member of my supervisory committee) for encouraging me and for effecting neccessary corrections during this write up.

I shall remain indebted to my dear parents, Alhaj Soolay and N-Fateeh Majin for their ever untiring support and fruitful advice which always give me the neccessary drive and guidance in all my endeavours. My special regards to my wife and children for their understanding and support given me through all the storms I went through during the M.Sc. programme.

Thanks to some of my colleagues such as Ml. Yahaya, M., Ml.: M. Musa, Ml.Musa Inuwa, Ml. Murtala Musa, Bagudu, Chucks, etc. and some workers at the Department of Agronomy, I.A.R/A.B.U, Zaria such as Mr. Achimugu, Ml. I. Yaro, Mr. Cyril, Vicky, Sani, etc. for their co-operation; and also, Ml. H. Mijinyawa at the Department of Sciences.

I wish to thank all my lecturers and friends as well as my brothers eg. Shehu Mohammad and sisters who, in no small amount, contributed to the success of this project. Finally, many thanks to some of my colleages at the Computer Center like Mr. Campbell and Mr. Vincent, and also Ms. Edith for their help during the final write up of this thesis.

May the Almighty bless all of you, (Ameen).

ABSRACT

A field experiment was carried out with two soybean, *Glycine mas* L., Merrill varieties namely Samsoy-2 and TGM-344 to study the influence of phosphorus levels (0. 35 and 70kg P_2O_5 ha^{-1}) and seed sizes (small, medium and large) on growth and yields of the crops at Samaru located in the Northern Guinea Savanna of Ngeria during the 1990 wet season.

Phosphorus at the rate of 35kg P_2O_5 ha^{-1} stimulated more growth and grain yield (1465.7kg ha'[1]) on these varieties than either 0 or 70 kg P_2O_5 ha^{-1}

treatments at this localityCultivation rM-344 had plants with vigorous growth but lower grain yield than the cv. Samsoy-2. The greater grain yield by Samsoy-2 could be attributed to its lower lodging (41.9 plants'plot) and higher one-hundred-seed weight (15.3g) than the TGM-344.

Plants raised from large seeds had more numbers of nodes, branches, pods and seeds/plant, 100-seed weight, total dry weight/plant and total grain yield than plants from either medium or small sizes of seeds.

The interactions of phosphorus and seed size on soybean varieties indicated that large seeds of fGM-344 produced plants with significantly more nodes/plant, tiller plants and more dry weight/plant at 35 kg *&2P5* na than the Samsoy-2 plants. It also generated more flowers, pods and seeds/plant.

There was significant positive correlation between Ihe grain yield/hectare and some agronomic qualities like the numbers of flowers, pods,branches and nods/plant, leal dry weight/plant, plant height and one-hundred-seed weight.

The cultivation of the cv. Samsoy-2 at Samaru locality should be encouraged using 35kg ha^{-1} *of* P_2O_5 fertilizers and large seeds for higher grain yield production.

TABLE OF CONTENTS

CONTENT PAGE

CONTENT PAGE

LIST OF TABLES

List of Appendixes

CHAPTER 1.

INTRODUCTION

1.1 Brief Botanical Description of Soybean

Soybean has the botanical numenclature, *Glycine max* (L.) Merrill, in the class of dicotyledon and a member of *leguminoseae* family *and Papilionoideae* sub-family (Dutta, 1974).

It is an annual crop and performs best in warn weather, usually on fertile and well drained soils, but some adapted cultivars can grow well in various climatic conditions (Anonymous, 1978). The plant has erect shoot that could be determinate or indeterminate in growth (Shibles *et al.*, 1976) and could attain heights of between 30 to 180cm at maturity. It is covered with fine velvet pubescence or hairs called trichomes. The main stem produces branches together with trifoliate compound leaves and clusters of small white or purple flowers some of which may form pods. A pod may contain from 1 to 5 seed (usually 2 or 3). Its root system is about 150cm long and spreads mostly in the 30 - 60cm depth of the soil. The root produces some small spherical or lobed nodules for nitrogen fixation,(Chapman and Cater, 1976, Norman, 1978 and Purseglove, 1974).

Soybean is a short-day plant that requires between 14 and 16 hours of darkness to produce flowers. Some varieties are late maturing and take 120 to 147 days before harvesting while some early and medium maturing cultivars take 98 to 110 days (Anonymous, 1988 and Purseglove, 1974).

1.2 History and Distribution

The crop was first described in an ancient Chinese work called *Materia Medica* or *Pen Ts'ao Kong Mu* since the year 2838 B.C. It could have been cultivated over 5000 years ago and was amongst the "Five Sacred G r a i n s" of the Orient including rice, wheat, barley and millet. The ancestors of the culivated soybean might have been similar to the wild species, *Glycine ussuriensis*, Regel and Maarch, which was reported to be abundant in Central China, Manchuria and Korea. These places could have been the centres of origin of the cultivated species (Robinson, 1947, Markley, 1950, Ala *et al.*, 1980 and Anon. 1985).

It was from these centres that the crop could have spread all over the world. It was known in Europe around 1712 but was brought to England and grown in the Royal Botanical Garden, Kew in the year 1790. Eventually its seeds were produced from some Chinese and Japanese cultivars in 1875 which resulted in its spread all over Europe (Caldwell, 1973 and Purseglove, 1974) .

In 1829 it was reportedly grown in parts of North America but was introduced into the United States of America in about 1873 and again in 1898 by the missionaries returning from China and Japan (Robinson, 1947 and Markley,1950).

The earliest cultivation of soybean in Africa was by the French in Algeria in the 1800s. It spread to East Africa by 1908, the same year it was reportedly, first introduced to the Moor Plantation, Ibadan, Nigeria, without success. The adapted Malayan cultivar was however grown successfully at Samaru, Nigeria, in 1928. Many other adapted cultivars from various parts of the world were also cultivated in different parts of the country by 1937 which facilitated its spread nation wide (Bich, 1982, Nyiakura, 1982, Dinakin, 1986 and Singh *et al*., 1987).

1.3 Importance and Production

Being one of the richest vegetable food crops and an industrial raw material, the significance of soybean to mankind lead to its increased production in various parts of the world. Uhlmann (1990) cited that cultivation of the crop was on the increase in many parts of Europe to meet the increasing demand for protein feed and vegetable oil. The seeds/grains are of 92% digestible nutrient quality of which 35 - 40% is protein . The oil content varies between 18 and 20% while carbohydrate and ash constitute 35.0 and 4.8% respectively (Dutta, 1974 and Mijindadi, 1987).

Whole soybean seeds could be used to make local foods eg. 'akara' or 'kosai', 'moin-moin' or 'alele', etc. or it could be blended with other food grains to enrich their protein contents. It can be used to thicken soup (Anonymous, 1985). Most soybean oil prod uced are used as food and some edible products like, margarine,cooking and salad oils, shortening, mayonnaise etc. While the non-edible soy-oil products include inks, sealing compounds, varnishes, candles, insecticides, glues, plywood adhensives, linoleum, phar maceuticals, plastics, detergents, disinfectants, etc. lecithin, also from the oil, is used in the manufacture of chocolates, macaroni, cosmetics, soaps, and antioxidants (Markley, 1950 and Purseglove, 1974).

Soybean cake/meal, i.e the product left after oil extraction, contains the most complete amino acid profile of all oil-seed cakes but with lower Methionine (Bamgbose *et al.*, 1989) and Cystine (Deregowda and Jain, 1990). It is rich in vitamines like thiamin, riboflavin etc. and also mineral nutrients for example phosphorus, calcium, iron, etc (Nyiakura, 1982).

No crop has ever been more allied to industrial development than soybean and its products (Wittwer, 1978). The soy-protein is utilised in the manufacture of ice cream, soy-milk, confection, bread, many baked foods and an enriched pap called "Soy-ogi". Artificial "Meat" of similar texture to beef have been developed from it. United Nations and humanitarian agencies use soy-protein and soy-milk as relief materials to improve diet in refugee camps (Burnett, 1951 and Orthoefer, 1978). The plant is useful as "green manure" and could enhance soil fertility when grown in rotation with cereals. It is also involved in making livestock and poultry feeds and in fattening calves, lambs, pigs, etc. (Caldwell, 1973 and Delorit *et al.*, 1974). According to Egba (1990) soybean contains substances capable of destroying HIV virus that causes AIDS and can also prevent cancer and coronary ailments.

The bulk of soybean produc ed in Nigeria is consumed locally as traditional condiment - 'kula' or 'Daddawa' or 'Iru', cooking oil and local foods etc. Some agrobased industries such as Taraku oil mill, Bendel food and flour mill, etc process the grains into desired products. Nestle company limited uses soybean to produce vegetable oils, flours, Nutriend (a weaning food), Golden morn (a breakfast food), etc. (Singh *et al.*, 1987 and Anon., 1991). This creates the need for increased production of the crop in this country.

The great world wide demand for oil after the world war 2 triggered increased production of the crop the world over. In 1988, total world soybean production was 92.3 million Metric tonnes (MT). The United States, the world's greatest producer, had 41.9 million MT followed by Brazil (18.1 million MT) , China (10.9 million MT) and Argentina (1.0 millon MT). Africa produced 473,000 MT with Nigeria, the largest African producer, contributing only 75,000 MT of grains (Anon.,1988).

However, the recent roles of governments, industries, research institutes and the Nigerian soybean scientists have progressed in boosting its production particularly the ban imposed on imports of vegetable oil by the Federal Government. This has made some oil mills utilise more soybean as raw material thereby stimulating greater production in the country with Benue State leading Kaduna, Niger, Bauchi, Kwara, Oyo, Bendel, Plateau, Anambra States and Abuja , in the crop production (Anon., 1983, Oyekan, 1987 and Singh *et al.,* 1987). Fordham (1991) estimated the current soybean production in this country at about 150,000 metric tonnes per annum while the estimate to meet the nation's needs is about 250,000 tonnes annually (Aku, 1988).

1.4 Phosphorus and seed size

Phosphorus is the back bone to life, due chiefly, to its involvement in nucleic acids formation. It is also involved in chemical energy processes in plants. This nutrient element affects the performance of crops and seed yields by legumes may be greatly reduced in soils deficient in P (Janick *et al.,*1974 and Evans, 1976).

The root nodules production by legumes, which enhances nitrogen fixation, is affected by the level of phosphorus in the soil (Israel,1987) and and it also promotes healthy shoot growth. The nutrient has been found to increase soybean dry matter production, plant height and root development. The deficiency of P in plant nutrients causes glaring symptoms such as poor root development, dark dead patches or violet colours on leaves, stunted growth, etc while too much of it could be toxic. Thus there is the need for application of correct levels of P-fertilizers (Paikere *et al.,* 1989).

Seed size is a factor which has been studied in a number of economic species such as legumes, cereals and forage crops ever since 1893 (Gelmond. 1978). The seeds can be sorted into various categories of large, medium, small etc. This has been recognised as crucial for soybean growth and grain yield. Teixeira and Costa (1989) found that soybean dry weight increased with varying seed size from small, medium to large seeds.

1.5 Problems and justification

Phosphorus nutrient is continuously removed from the soil by plants and other organisms. Much of its is also lost in sewers and soil erosion into rivers and oceans etc. This lost can only be efficiently replaced fast enough by application of phosphorus fertilizers at optimum levels/rates (Cooke, 1975) and thus the necessity of this research work.

Gelmond (1978) reported that heavier wheat seeds produced greater yields. Even in cowpea seed size have been found to affect yields and this creates the need to investigate the seed size influence on soybean growth and yield.

There are, of courses, several other problems that affects the production of soybean particularly in this country like rapid seed deterioration in storage, popularity amongst the populace, etc. Effort must be made collectively to overcome these problems so as to encourage larger production of the crop.

1.6 Objectives

This research project was initiated, therefore, with the following objectives:-

1. To investigate the influence of three phosphorus levels on growth, yield and yield components of two soyabean, *Glycine max* (L) Merrill, varieties.

2. To study the effect of three seed sizes on growth, yield and yield components of two soybean varieties.

3. To assess the interaction of phosphorus levels and seed sizes as they affect growth, yield and yield components of the two varieties.

CHAPTER 2

LITERATURE REVIEW

2.1 Rates and Methods of Phosphorus Application

Phosphorus nutrient is required by soybean plant at all stages of growth because it promotes growth and development of plant parts especially the root system (Dutta, 1974). In a trial, Barber (1980) noted that the response of soybean (*Glycine max* (L.) Merrill) to phosphorus was affected more by it level in the soil.

Soil conditions should initially be considered carefully before any judicious level of phosphorus is applied since the soil phosphorus level affects the growth and yield of soybean (Barber, 1980). Application of upto 60kg P_2O_5 ha^{-1} has been reported to have increased soybean seed yield remarkably (Sergeer, 1978).

The most effective response of soybean to phosphorus is through application of super phosphate fertilizers or calcium phosphates at the right amount suitable for a soil type (Ewer and Hall , 1978 and Tanimu *et al.*, 1982).

In the Nigerian Savanna, the amount of P-fertilizer required to produce maximum yield of soybean is not often high. One of the earliest investigations on P-application to soybean dated back to 1957 in the Southern Guinea Savanna of this country (Goldsworthy and Heatheote, 1964 ; Olufajo *et al.*, 1984).

For grain yields of about 3,000kg ha^{-1}, Bhangoo and Albritton (1972) reported that some varieties of soybean required only about 33.6kg

ha^{-1} of available P_2O_5 but this depended largely on the soil condition and an additional phosphorus could further increase seed yield.

In a trial, Queiroz *et al.* (1980) observed that some varieties required a high dose of this nutrient to cause any effect at all on its characteristics. The cultivar Vicoja treated with varying levels of phosphorus up to 640kg P_2O_5 ha^{-1} produced insignificant responses.

The uptake of fertilizer P increases with its increasing rates but decreases with increasing soil fertility gradient (Mahajan *et al.*, 1982). In some cases yields often increase with increasing rates of this nutrient to the highest levels (Cheng and Cheng, 1986; Gonzalez *et al.*, 1987).

One of the best methods of P-application to soybean is by supplying supper phosphate (Calcium Phosphate) fertilizers to the soil at appropriate levels. In row crops, this could be done by placement of the fertilizers at about 5.0cm to the side of the crops and 7.5cm below soil surface, to achieve greater effect than by broadcast methods (Cooke, 1975). Soybean, according to Barber (1980), may not respond to fertilizers banded near the seeds at planting but needs a high phosphorus to the root zone in the soil when the plant is 50 to 80 days old but good timing of P-application could induced good crop yield.

Costa and Sfredo (1980) showed that seed germination of Parana cultivar was not significantly affected by P-application in bands or broadcast. However, Souza *et al.* (1984) observed that P, Ca and Mg concentrations in the crop were also increased by applied phosphorus.

2.2 Phosphorus and Growth of soybean Plant

Generally, phosphorus is used by plants for the formation of phospholipids in the cell membranes, some proteins, nucleic acids and nucleotids, phosphohexose and triose sugars, some co-enzymes and also for energy transduction in living organisms (Vines and Rees, 1971; Roberts, 1986). Most crops, according to Ewer and Hall (1978) showed much responses to phosphate fertilizers even on soil just cleared from fallow. Phosphorus promotes nuclear and cell divisions, hastens maturity and ripening of fruits particularly of grains. Underground structures of some crops require phosphorus for normal development (Dutta, 1974).

The macronutrient impacts glaring deficiency symptoms like, poor root growth and development, purple or dark-green dead patches on leaves and stunted growth of plants, (Vines and Rees, 1971 and Clegg, 1980).

2.2.1. Growth of the root and phosphorus

The growth and development of soybean root system was promoted by application of phosphorus at the right level especially with other nutrients like aluminium, zinc and lime, (Zakaria *et al.*, 1977). Jone *et al.* (1977) reported an increase in number of root nodules per plant and per unit soil volume due to phosphorus treatment. Its severe deficiency in a soil impaired the growth of the plant together with its symbiotic bacteria for nitrogen fixation (Israel, 1987).

In a trial, Lauer and Blevins (1989a) revealed that the root-nodule *Rhizobium* sp. exerted phosphorus demand on plants irrespective of its status in the soil and the whole root and its nodules retained some of this nutrient when the supply was limited some of which may be mobiled to other plant parts when desired. Cassman *et al.* (1980) were of the view that a decrease in P-supply to soybean plant inhibited root nodule growth.

Hallmark and Barber (1981) observed increased root surface area and root weight with increasing P-rates on soybean. This will enhance the

Hallmark and Barber (1981) observed increased root surface area and root weight with increasing P-rates on soybean. This will enhance the absorption of soil solution for healthy growth and development of these plants.

In other crops such as cowpea, Adepetu and Akapa (1977) found that the efficient utilizlation of phosphorus fertilizers depend to a large extent on the amount that contacts the root system. Applied P also increased root nodules per plant of cowpea (Singh and Jain, 1966).

Actually, all these increases in root surface areas and nodulations would lead to better growth and development of soybean. The large surface area of the root would increase absorption of soil solution while more nodulation could increase nitrogen fixation, thus, promoting growth and development of the crop. The nutrient is required by soybean at all stages of growth. Plants use their roots to obtain their phosphorus requirements via soil solutions in forms of orthophosphate ions, viz $H_2PO_4^{-}$, HPO_4^{2-} & PO_4^{3-}, *depending on soil type and condition,* (Cooke, 1975).

2.2.2 Growth of the shoot and phosphorus

Pal and [illegible] (1988) found that this element was the most growth limiting nutrient in Nigerian Savanna soils particularly for cultivar Malayan. Increasing P-level to the soil as Vieira *et al.* (1986) cited, stimulated production of more stems and leaves of soybean. Taller and heavier plants were also attributed to the influence of increasing levels of P-fertilizers on, especially, UFV-2 and Cristalina.

Investigation of Hallmark and Barber (1984) revealed that the addition of P element to soybean had more effect on shoot growth than even the root. The lower leaves of soybean usually serve as storage structures for excess Phosphorus in the shoot from where it could be mobilised to other part when necessary. Phosphorus content of the leaves, stems and total tops of soybean at prebloom stage were found to be 0.30, 0.15 and 0.25 % respectively. At bloom the values dropped to 0.17, 0.07 and 0.14% while at pod filling the percentages fell further due mainly to the translocation of P to the pods for the development of seeds (Norman, 1963).

The increase in soybean leaves, stems, height and dry weight due to increase in applied phosphorus would certainly increase it photosynthetic capacity and this would cause more shoot growth. According to Chiezey (1990) phosphorus application to soybean increased its numbers of leaves and branches per plant, plant height and dry weight. Lauer and Blevins (1989a) concluded that soybean dry matter and phosphorus accumulation were greatest when William - 82 cultivar was given 0.45 millimole (mM) phosphorus in hydroponic culture and lowest with 0.05mM treatment.

In other crops like cowpea and strawberry, phosphorus promoted formation of new leaves and increase in number of leaves per plant, number of fruits per plant, earliness to flowering and grain yields (Sanchez *et al.*, 1976 and Yusuf, 1987). Generally the productivity of crops was limited more frequently by phosphorus availability than by any other nutrient but nitrogen, (Cure *et al.*, 1988)

2.3 Phosphorus, Soybean Yield and Yield Components

Phosphorus quickened soybean maturity and ripening of grains. But profitable grain yield from applied phosphorus has been reported in the field only when available soil phosphorus content was very low and in presence of other nutrient elements. High rates of applied P should be followed by application of potassium fertilizers to maximise the grain yield, (Caldwell, 1973 ; Yoon and Ryu, 1976).

Its role in promoting cell and nuclear divisions would have contributed more living materials for the production of more grains in plants. According to Bharati *et al.* (1986), increasing P-rates resulted in more leaf phosphorus and lodging which caused severe grain yield reduction. Phosphorus influenced increase in soybean height and vigorous vegetative growth which could lead to lodging (Norman, 1978).

In some soils Haque *et al.* (1980) pointed out that there existed a positive and linear correlation between phosphorus levels and soybean seed yield but the seed protein content was not affected. Caldwell (1973) indicated that the nutrient element also increased pod weights and grain yields of soybean. Further more Hampaih and Sinha (1980) found that increased seed and fresh fodder yields of the crop was due to increasing rates of phosphorus to a certain limit after which no significant increased was noticed.

In an experiment Lauer and Blevins (1989b) reported that increasing phosphorus treatments increased floweirng, pod production and abortion, seed weight and number, together with increased seed yield particularly for soybean cultivar William - 82 grown in hydroponic culture.

In some cases increasing P-rates may not affect some growth characters but Clark-63 variety gave highest seed yield of 1.9 tons ha^{-1} with 60kg P_2O_5 ha^{-1} compared to 1.3 tons ha^{-1} of the control i.e. without any P-treatment. The macronutrient increased the oil contents of soybean, groundnuts and sunflowers (Lamara and Pava, 1983 ; Appelquist, 1979).

Application of P increased soybean grain yield. It also delayed flowering probably to prolong the vegetative growth of the plant to allow accumulation of nutrients which may be translocated to seed sinks at grain filling stage, (Chiezey, 1990). Seed and dry matter yields of soybean and the uptake of phosphorus increased with increase in soil fertility gradient of P-levels between 0 to 90kg P_2O_5 ha^{-1} (Mahajan *et al.,* 1982).

To maximise soybean grain yield, Lins and Cox (1989) found that the rate of phosphorus required by the crop was dependent on the concentration of extractable phosphorus along with other chemical and mineralogical characteristics of the soil. From a practical point of view clay content and extractable P offered the best means of predicting the correct P-rates for a soil type to produce more yields.

Phosphorus nutrition had significantly increased yields and P contents of soybean and Oat in presence of other nutrients such as lime and potassium (Matar, 1977 and Yuan *et al.,* 1979).

Other legumes also responded to phosphorus treatment. For groundnut (*Arachis hypogaea,* L.) application of P_2O_5 up to 50kg ha^{-1} significantly increased kernel prouction, oil content, growth and more P uptake by the crop, (Zalawadia and Patal, 1983). In Okra (*Abelmoschus esculentus,* L.), Majanbu *et al.* (1989) observed significant increases in green pod yield, pod number and number of seeds per pod with application of this nutrient. Some cereals responded to phosphorus treatment only at suitable cimatic factors especially adequate rainfall distribution. In wheat (*Triticum aestivum*) and Lentil (*Kus esculenta*) high phosphorus responses were recorded in dry unproductive seasons and a negative linear relationship was realised between the response to phosphorus and absolute yields of these crops. Thus it was postulated that phosphorus also improved cereal crops tolerance to aridity. (Matar, 1977 and Yuan *et al.*, 1979).

Soil moisture content also affects phosphorus uptake by soybean. Marais and Wiersman (1975) noted that the extent of phosphorus absorption by the roots was impaired by high moisture stress. Plants exposed to high water stress resumed P-uptake at a rate exceeding those of plants absorbing phosphorus from the adequately watered compartments. Moisture stress appeared to affect P-uptake largely through its influence on diffusion of soil solution into the roots.

2.4 Variation in Seed Size

The seed size of many agricultural crops vary from small to large. A lot of work on the influence of seed size on different crops has been on the increase all over the world. Hampton (1981) reported that variation in seed size tend to follow the pattern of normal distribution. The effect of this factor on growth and yield of soybean has been under investigation for more than 75 years (Smith and Camper Jr., 1975).

Infact ever since 1893, the effect of different sizes of seeds on germination, seedling emergence, subsequent growth and ultimate yield on a number of economically valuable plants has received intensive attention from many researchers. It has been detected that large/heavier wheat seeds produced more yields. Seed size also affected soybean emergence, vigour, growth, and grain yield. A positive relationship reportedly existed between seed size, vegetative growth and/or seed yields in several legumes and grasses (Smith and Camper Jr. 1975 and Gelmond, 1973).

Williams (1950) cited that weights of soybean seeds vary from 30mg for small to about 570mg for large ones. Song *et al.* (1990) also reported that 100-seed weights of 2,748 soybean varieties ranged between 7.3 to 48.4gm. Most U.S.A. soybean varieties have a seed size of 12 - 19 gm per 100 seeds (Norman, 1978). The wild species of soybean namely, *G. ussuriensis*, Regel and Maarck, has a mean weight of 890mg per seed. On diameter basis, small and large soybean seed sizes may average between 4.0mm and 7.0mm respectively, (Teixeire and Costa, 1989).

2.5 <u>Seed Size and Soybean Growth</u>

2.5.1 <u>Growth of the root and seed size</u>

Egli *et al.* (1978) stated that the rate of seedling growth was related to the size of seed. Germination rate was greater for medium sized seeds than large or small ones. The germination percentage of large , medium and small seeds of varieties Bragg and Ankur were similar but protein contents increased while the contribution of cotyledons to seed weights decreased with reduction in seed size. Germination is generally reduced in large seeds (Laddha and Gupta, 1979, Singh *et al.*, 1979 and Guiar, 1981). This could be because the large cotyledons could disturb the emergence of the germinating seed.

But in the findings of Mohammed *et al.* (1988) large soybean seeds produced greater elongation rates of the radicles than other seed lots. Caldwell (1973) recorded faster emergence and larger root development in plants from small and medium seeds than those from large ones. Actually the seedling growth rate was partially determined by the genetic make up of the seed.

The weights of soybean seed integuments, dry weight of root and cotyledons increased with increasing size of seed. (Teixeira and Costa , 1989).

Even in some cereals such as *Sorghum bicolor* (L.) Moench. crops produced from large seeds gave significant increases in germination percentages and root lengths over those of small and medium seed parents, (Singh *et al.*, 1980).

2.5.2 Growth of the shoot and seed size

Variation in seed size have a profound influence on shoot growth of soybean plants. Large seed usually have more emergence and greater vigour of seedling than other smaller seed grades (Hampton, 1981). Xu *et al.* (1978) discovered that the greatest sprout was produced from large seeds of soybean.

According to Shibles *et al.* (1976) larger soybean seed had poor emergence primarily due to its large cotyledons that provide excessive resistance during emergence, in medium to heavy soils and viability could also be lowered due to susceptibility to handling damage because of the size.

Investigation on soybean seedlings revealed that maximum vertical elongation force (EF) exerted by the emerging seedlings was correlated to seed size in which large seeds had greatest elongation force (Inouye and Jin, 1982). And this would, of courses, enhance emergence of seedling at germination.

In bulk population, the findings of Fontes and Ohlrogge (1972) emphasized that large seeded soybean plants had wider stem diameters, more numbers of barren plants and branches than small seeded ones. A positive correlation was found to exist between seed size and seedling vigour. An increases in soybean dry weight, branches and seeds per plant has been due to increasing size of seed. (Major, 1977 and Whitehead, 1980).

Then Burris *et al.* (1973) in a trial, concluded that large soybean seed produced greater over all emergence percentage, leaf area and plant height in the field than other seed categories while Carelli and Fahl (1979) noted no any seed size effect on soybean grown in green house.

In another field experiment, Chin (1977) found that increased dry matter, leaf area and leaf weight were caused by increase in seed sizes of *G. max* and *Phaseolus* sp.

In other crops, for instance alfalfa, seedling vigour was significantly correlated to seed size (Breveridge and Wilsie, 1959). Subterranean clover gave more dryweight, total leaf area and number of leaves with increasing seed size and in birds-foot trefoil

(*Lotus corniculatus*, L.) large seed produced larger seedling and improved establishment of crops than small ones (Black, 1956) and Mckersie *et al.*, 1981).

Musa (1990) also reported that in cowpea, seed size influenced vine length, number of leaves per plant, leaf dryweight, leaf area and shoot dryweight.

The seed size factor has been shown to influence the emergence and early growth of seedlings of many forage legumes, (Haskins and Gorz, 1975).

2.6 Seed Size and Yield with Yield Components

The yield from large seeded soybean plants was significantly more than that of small seeded ones when grown at uniform populations. In some cases the average grain/seed yields of plants from large seeds exceeded those yield from small seeds but the yields of plants from small seeds equalled those of medium seeds while no effect was observed on plant stand, mortality and lodging (Burris *et al.*, 1973 ; Smith and Camper Jr., 1975).

Fontes and Ohlrogge (1972) cited that seed size played an important role in the interspecific competition between soybean populations. When large seeded varieties were interplanted with small seeded ones, the grain yields and number of pods per plant was more for large seeded plants than the small seeded ones. In a field trial Carelli and Fahl (1979) discovered greater numbers of pods and seeds in soybean plants from large seeds than other sorts of seeds.

The proportion of oil, reducing and non-reducing sugars increased with seed size, but the number of pods per plant was less variable, (Reddy *et al.*, 1989 and Shukla *et al.*, 1987). Large seeds of soybean gave more grain yield per hectare than small sized seeds under similar favourable conditions (Sisodia, 1987).

Even in other crops, seed size influenced their yields. Hampton (1981) reported that some wheat cultivars from large seeds out yielded plants from small seeds by maintenance of more ears per m^2 but no other yield components were significantly affected. In some varieties of wheat, Salnikov (1977) noted a decreased in the activities of hydrolytic and redox enzymes in the seedlings of small seeds than those of large ones. According to Hampton (1981) when equal number of wheat seeds were sown, large seeds out yielded small ones by between 3 - 17%.

Pearl Millet also produced more ear heads, total weights per plant and grain yields from large seeded crops than from small or medium seeded ones, (Kawande *et al.*, 1988). In *Sorghum bicolor* (L.) Moench. crops grown from large seeds gave significant differences in 100-seed weights than other seed sizes, (Singh *et al.*, 1980), while Sahabi (1988) indicated that large cowpea seeds gave higher yields than medium and small seed sizes although there was no significant differences in the yields of medium and small seeds.

2.7 Interactions of Phosphorus and Seed Size on Soybean Growth and Yield

2.7.1 Phosphorus and variety interaction

The interaction of phosphorus treatment and variety of soybean on the growth and yield of the crop has been observed by many researchers lately. Phosphorus nutrition affects plants differently depending on the soil type.

Afolabi and Osiname (1980) discovered that when two soybean varieties, viz. cv. Bossier and Improved Pelican, were given 30 - 45kg P_2O_5 ha^{-1} in the forest soil both exhibited similar responses. But in the savanna soil the Bossier variety responded to P better than the Improved Pelican. According to Vieira *et al.* (1986) when cv.s Cristalina and UFV-2 were treated to varying P-level of up to 330kg P_2O_5 ha^{-1}, cv. Cristalina had plants with greater weights, heights, more numbers of pods and seeds per plant than the UFV-2. But the UFV-2 variety produced greater yield.

In another experiment three soybean varieties were given O, 80, 160, 320 and 640kg P_2O_5 ha^{-1}, cv. Vicoja didn't respond significantly to any of these treatments. Cv. Parana yielded 1.80 tons ha^{-1} without P and 2.41 ton ha^{-1} with 640kg P_2O_5 ha^{-1} while the yield from Bossier variety increased from 1.85 to 2.13 tons ha^{-1} with 320kg P_2O_5 ha^{-1} treatment (Queiroz *et al.*, (1980).

2.7.2 Seed size and variety interactions

Mohammed *et al.* (1988), in studies with soybean cultivars William, Lee and Clerk - 63, reported that a significant seed size and variety interaction existed on various soybean qualities. In a trial, Teixeira and Costa (1989) found that the shoot dry weight of soybean increased with increasing seed size but was more for cultivar Ivora than cultivar Decada. The root dry weight also increased with seed size of soybean but more for cv. Decade than Ivora variety.

The cultivar x seed size interaction was highly significant for maturity, numbers of pods and seeds per soybean plant, seed yield per plant, protein and oil contents for five (5) soybean varieties (Reddy, 1989).

CHAPTER 3

MATERIALS AND METHODS

3.1 Site of the Research

This study was conducted at the experimental farms of the Institute for Agricultural Research, Samaru, ABU, Zaria, Nigeria. Samaru is locate in the Northern Guinea savanna 11^{o} 11' N and O7^{o} 38' E. The soil types range from sandyloam to clayloam with an averagely low cation exchange capacity. The soil is well drained (Kowal and Knabe, 1972 ; Komolafe *et al.*, 1980).

3.2 Treatment and Experimental Design

There were three treatments comprising of phosphorus, variety and seed size. The phosphorus treatment was of three rates viz, O, 35, and 70kg P_2O_5 ha^{-1}. The two varieties used were Samsoy-2 and TGM - 344, while the three seed sizes included small, medium and large seeds making a total of eighteen different treatments.

These treatments were laid out in a split plot design and replicated four times. There were six main plots comprising of factorial combination of three (3) phosphorus levels and two (2) soybean varieties. Each main plot contained three (3) subplots of the seed size treatments.

Each gross plot has a dimension of 4.5 x 6.0 meters ($27m^2$) and contained six ridges, each 75cm apart. The net plot size was 3.0m x 6.0m ($18m^2$) with four inner ridges. A path of about a meter wide was left between the plots for accesibility to each plot.

3.3 Grading Seeds into Sizes.

The seeds of the two varieties were obtained from the Agronomy Department I.A.R. Samaru, A.B.U., Zaria. These were initially sorted into small, medium and large sizes visually for each varietry. Then metal sieves of different sizes collected from the civil engineering department ABU, were employed for grading of the seed lots into the various sizes accurately. The seeds of Samsoy - 2 cultivar were graded into 5.4, 4.8 & 4.4mm diameters for large, medium and small seeds respectively. For TGM-344, large seed was 5.0mm and medium and small seeds have diameters of 4.6 and 4.2 mm respectively, using different sieves for the sorting.

100-seed weights (gm) for each sort of seeds for the two varieties used were also recorded. The large, medium and small seeds of Samsoy-2 weighed 191.2, 153.4 and 112.3gm per 100 seeds respectively. The TGM-344 however weighed 165.6, 128.7 and 94.2gm for large, medium and small seeds per 100, respectively.

3.4 Cultural Practice

3.4.1 Land preparation

This was carried out in early July 1990 by discploughing and harrowing the soil to a clean and fine tilth using a tractor. The field was uniformly ridged at 75cm interval and each of the seventy-two plots was marked out with pegs and labelled accordingly.

3.4.2 Sampling and analysis of the soil

Soil testing was accomplished from a composite sample collected from the project farm before any application of fertilizer. Initially the farm was divided into may equal quadrats and several soil samples were collected from each quadrat to a depth of 30cm. These were then bulk together to obtain a representative sample for analysis.

The physico-chemical characteristics of the soil were determined. The hydrometer method was used for the assessment of soil texture (Day, 1965). The soil total nitrogen content was determined by micro Kjeldhal method (Bremmer, 1965) and the extractable phosphorus content of the soil was determined by ammonium-molybdate blue method (Bray and Kurtz, 1945). The exchangeable bases were extracted, then calcium and magnesium were determined by the atomic absorption spectrophotometry (AAS) while sodium and potassium were determined by flame emission spectrophotometry (FES). The soil pH was determined using pH meter. The organic carbon content was analysed by Walkley-Black method (Allison, 1965 and Chapman, 1965), see appendix 1.

3.4.3 Planting

The seeds were planted in early July 1990 at the rate of 40kg ha^{-1}. This was done manually, on the ridges at a seedling depth of 2.5 to 3.0cm and one seed per hole at a spacing of 5.0cm between stands. All the missing stands were filled after emergence.

3.4.4 Fertilizer application

A basal fertilizer of about 25kg N ha^{-1} in form of calcium ammonium nitrate (CAN) was broadcast uniformly over the farm after the germination of the seeds as starter nitrogen dose. Application of the phosporus treatments using single super phosphate (SSP) was done by side placement at about 5.0cm beside the plants and 7.5cm below soil surface. All P treatments were applied next days after planting.

3.4.5 Weed and pest control

Weeds were controlled by hoe weeding which was done twice, at 3 and 6 weeks after planting (WAP). This was later supplimented by hand-pulling of weeds whenever necessary up to harvesting time.

The seeds planted were healthy but an insecticide, thiodoan ULV, was applied to the seedlings after their establishment to check insects .

3.4.6 Harvesting

The crops were harvested when the leaves turned yellow-brown and have started falling off, by hand pulling the plants in the net plots. These were separately gathered, dried for a few days in the field and then threshed. The seeds were cleaned by winnowing and the weight of seeds for each plot was taken to determine the grain yields.

3.5 Data Collection and Observations

3.5.1 Meteorological data

The data of rainfall, temperature and relative humidity prevailing during the research period were collected from the meteorological station at IAR, Samaru, Zaria, (Appendix 2).

3.5.2 Agronomic data

These are the records of the assessments of the agronomic characteristics used in studying the effect of the treatments on soybean varieties during this project. Many of these parameters were recorded at regular/specific time intervals before harvest while a few others were assessed at harvest and post-harvest.

Random samples of five plants were taken from each plot for determining each of the various observations.

Five plants per plot were tagged for assessing some charaters like plant heights, numbers of flowers, branches, nodes and pods per plant. For studying the leaf area per plant, leaf dry weight per plant, and total dry weight per plant, the samples were initially uprooted and washed carefully before observations were recorded. The number of days to 50% flowering was determined when half of plants in the net plots had flowers. The number of lodged plants per plot was also recorded for each plot.

Growth characters such as number of branches per plant and plant heights (cm) were determined beginning from six weeks after planting and continued till harvest at four weekly intervals while number of flowers per plant was counted at two- week interval.

Leaf area (cm^2) and leaf dry weight (gm) per plant, number of nodes per plant and total dry weight (gm) per plant were initially recorded at eight weeks after planting then at two- week intervals until harvest.

The leaf area (cm^2) per plant was measured by counting the squares covered by the outlines of the leaves which were spread on graph sheets as described by Sestak *et al.* (1971). The total dry weight and leaf weight per plant were taken fresh and oven-dried at 70°C to constant weights then the final weights were recorded. Plant heights were taken with a meter rule.

At harvest the number of lodged plants per plot was assessed using initial stand after the emergence. Starting from eight weeks after planting, the number of pods per plant was recorded at four weekly intervals. Yield component qualities assessed include number of seeds per plant, 100-seed weights (gm) and grain yield (kg ha^{-1}).

3.5.3. Statistical analysis of data

All the data collected were subjected to analysis of variance as described by Snedecor and Cochran (1977) for the test of significance of the various treatments. Treatment means were subjected to the Least Significant Difference(LSD) at 5% level of probability to determine the significant differences among them . Finally, the correlation coefficient (r) analysis was used for evaluating the relationships between grain yield of soybean with other agronomic characters (Duncan, 1955).

CHAPTER 4

RESULTS

4.1 Influence of Phosphorus and Seed Size on Growth of Two Cultivars of soybean.

4.1.1 Plant height

Phosphorus application significantly affected plant height through out the sampling periods. At 6 weeks after plant (WAP), plants supplied with 35kg P_2O_5 ha^{-1} were significantly taller than those supplied with either 0 or 70kg P_2O_5 ha^{-1} which were not significantly different in height from each other. At 10 WAP all the phosphorus levels produced significantly different heights and at 14 WAP, 35kg $P_2O_5ha^{-1}$ gave plants that were significanly taller that those supplied with 70kg P_2O_5 ha^{-1} which were in turn significantly taller than the plants given 0kg P_2O_5 ha^{-1}. At harvest 35kg P_2O_5 ha^{-1} produced the tallest plants that were, however, not significantly different from those treated with 70kg P_2O_5 ha^{-1} but both were significantly taller than plants given 0kg P_2O_5 ha^{-1} (Table 1.).

The varietal effect on plant height was also significant. The cultivar TGM-344 was significantly taller than Samsoy-2 throughout the sampling period. Seed size had significant effect on plant height up to the time of harvest. Large seeds produced plants with significantly greater heights than other seed lots.

There were two significant interactions of the treatment on plant height at 10WAP and at harvest.

Table 2 shows the effect of P x V x S interaction on soybean height at 10WAP. large seed of cultivar TGM-344 produced the tallest plants when supplied with 35kg ha^{-1} of P_2O_5 which w

Table 1. Effect of phosphorus, variety and seed size on plant height (cm) at Samaru, 1990 wet season.

Treatment	Weeks after planting 6	10	14	Harvest
Phosphorus levels ($kg\ ha^{-1}$)				
0	20.2b	32.1c	50.8c	56.9b
35	21.7a	37.9a	56.1a	59..2a
70	20.0b	36.5b	54.5b	58.3a
S.E ±	0.38	0.39	0.45	0.33
Varieties				
Samsoy - 2	17.4b	30.4b	43.5b	44.3b
TGM-344	23.8a	40.6a	64.1a	71.9a
SE ±	0.40	0.41	0.34	0.35
Seed sizes				
Small	19.3b	34.7b	52.7b	57.9b
Medium	20 3b	35.0b	53.2b	58.0b
Large	22.3a	36.7a	55.6a	59.5a
SE ±	0.38	0.52	0.42	0.33
Interactions				
P x V	NS	NS	NS	NS
V x S	NS	NS	NS	NS
S x P	NS	NS	NS	*
P x V x S	NS	*	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 5% probability. * = significant at 5% level of significance.

NS = Not significant at 5% level.

Table 2. Interaction of phosphorus, variety and seed size on plant height (cm) at10 weeks after planting at Samaru, 1990 wet season.

Varieties	Seed sizes	Phosphorus levels (kg ha^{-1})		
		0	35	70
	Small	27.8i	31.3f-i	29.0hi
Samsoy-2	Medium	28.9hi	34.6ef	31.4f-i
	Large	30.9ghi	37.8cde	32.9fgh
	Small	33.3fg	41.8ab	40.0bcd
TGM-344	Medium	34.8e	43.8a	41.1abc
	Large	35.1e	44.2a	43.9a
SE ±			1.22	

Means followed by the same letter(s) within a treatment group are not significantly different at 5% probability.

statistically taller than Samsoy-2 plants at all the seed sizes and phosphorus levels. The shortest plant was recorded for small seed of Samsoy-2 treated with 0kg P_2O_5 ha^{-1}.

A significant interaction of phosphorus against seed size was observed at harvest on plant height. When P-level was increased to 35kg ha^{-1}, large seed had plants that were significantly taller than all the other seed categories treated to the various phosphorus levels (Table 3).

4.1.2 Number of branches per plant

This parameter was not significantly influenced by P-rates at 6 and 10 weeks after planting (WAP). However, at 14 WAP the plants given phosphorus fertilizers produced significantly more branches per plant than those that had no phosphorus treatment.

The effect of variety on the number of branches per plant was significant. Samsoy-2 plants produced significantly more branches per plant than TGM-344 plants throughout the periods sampled.

In the case of seed size effect, significant differences occured throughout the sampling periods. Large and medium seeds gave plants with relatively similar number of branches per plant but both had significantly more number of branches per plant than plants from small seeds at 6 and 10 WAP. At 14 WAP the plants from large sized seeds had significantly more branches than those from the other seed sizes. Plants from medium seeds in turn produced significantly greater number of branches per plant than those from small seeds (Table 4).

Table 3. Interaction of phosphorus against seed size on plant height (cm)at harvest at Samaru, 1990 wet season.

	Seed size		
Phosphorus levels (Kg ha^{-1})	Small	Medium	Large
0	52.8g	54.5efg	58.3bc
35	56.2de	58.5bc	60.9a
70	54.8 ef	57.9bcd	59.3ab
SE ±		0.59	

Means followed by the same letter (s) within a treatment group are not significantly different at 5% probability.

Table 4. Effects of phosphorus, variety and seed size on the number of branches / soybean plant at Samaru, 1990 wet season

	Weed after planting		
Treatments	6	10	14
Phosphorus levels(kg ha^{-1})			
0	4.0	6.7	7.9b
35	4.2	6.9	9.6a
70	4.4	7.1	9.9a
SE ±	0.12	0.16	0.23
Varieties			
Samsoy-2	5.3a	8.9a	12.7a
TGM-344	2.8b	4.2b	5.6b
SE ±	0.08	0.07	0.11
Seed sizes			
Small	3.6b	5.7b	8.1c
Medium	4.2a	6.8a	9.3b
Large	4.4a	7.1a	10.1a
SE +	0.11	0.14	0.13
Interactions			
P x V	NS	NS	NS
V x S	NS	NS	NS
S x P	NS	NS	NS
P x V x S	NS	NS	NS

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

NS = Not Significant.

Table 5. Effect of phosphorus, variety and seed size on number of nodes / soybean plant at Samaru, 1990 wet season

	Weeks after planting			
Treatments	8	10	12	14
Phosphorus levels				
(Kg ha^{-1})				
0	10.5	12.6	14.0b	14.3b
35	10.2	13.2	15.5a	15.8a
70	9.7	12.8	15.0a	15.3a
SE ±	0.29	0.26	0.25	0.28
Varieties				
Samsoy -23	9.3b	11.6b	12.7b	13.0b
TGM-344	10.9a	14.2a	16.9a	17.2a
SE ±	0.25	0.16	0.22	0.20
Seed sizes				
Small	9.1b	11.6c	13.6c	13.8c
Medium	9.9b	12.6b	14.9b	15.0b
Large	11.2a	14.3a	16.2a	16.5a
SE ±	0.32	0.32	0.36	0.36
Interactions				
P x V	NS	*	NS	NS
V x S	NS	NS	NS	NS
S x P	NS	NS	NS	NS
P x V x S	NS	NS	NS	NS

Means followed by the same letter (s) within each treatment group are not significantly different at 5% probability.

* = significant at 5% level of significance.   NS = Not significant.

Table 6. Interaction between phosphorus and variety on number of nodes/soybean plant at 10 weeks after planting at Samaru, 1990 wet season.

Phosphorus levels ($kg\ ha^{-1}$)	Varieties Samsoy-2	TGM-344
0	11.1d	13.1bc
35	11.9cd	15.2a
70	11.3d	13.7b
SE ±	0.43	

Means followed by the same letter(s) within a treatment group are not significantly different at 5% probability.

4.1.4 Leaf area per plant

The influence of phosphorus levels on leaf area (cm^2) per plant was significant from 8 weeks after planting (WAP) to 14 WAP. For both varieties leaf area per plant was greatest at 35kg P_2O_5 ha^{-1} followed by 70kg P_2O_5 ha^{-1} which were significantly different from those of soybean plants supplied with 0kg P_2O_5 ha^{-1} throughout the sampling periods.

The varietal influence was significant as from 8 WAP. The TGM-344 cultivar had significantly greater leaf area per plant than SAMSOY-2, throughout the sampling periods.

The effect of seed size on leaf area per plant was significant between 8 to 14 WAP. Plants from large seeds produced significantly greater leaf area per plant than those from the other seed grades. The medium seeds gave plants that had significantly higher leaf area per plant than those from small seeds all through the periods sampled (Table 7).

There were significant interactions of seed size and variety at 10 and 12 WAP. At 10 WAP, TGM-344 plants from large seed size gave signficantly greater leaf area per plant than all the other treatments. It was found that the differences in leaf areas of large seed of Samsoy-2 and medium seeds of TGM-344 were statistically insignificant while the medium seeds of Samsoy-2 and small seeds of TGM-344 had leaf areas that were not significantly different. Samsoy-2 plants from small seed produced the least leaf area (Table 8).

S x V interaction at 12 WAP revealed that large seed of TGM-344 had the greatest leaf area that was significantly more than all the others, but Samsoy-2 plants from small seeds gave the lowest leaf area which was

Table 7. Effect of phosphorus, variety and seed size on leaf area (cm^2)/plant of soybean at Samaru, 1990 wet season.

Treatments	Weeks after planting 8	10	12	14
Phosphorus levels (Kg, ha^{-1})				
0	1235.3c	1707.5c	3004.1c	1370.8c
35	1546.2a	2113.2a	3389.3a	1609.0a
70	1368.7b	1921.5b	3218.1b	1488.1b
SE ±	48.45	51.26	46.25	47.93
Varieties				
Samsoy-2	1384.5b	1721.2b	3015.2b	1406.9b
TGM-344	1598.8a	2027.6a	3389.1a	1598.2a
SE ±	41.00	31.60	36.62	31.11
Seed sizes				
Small	1187.5c	1415.5c	2714.2c	1137.5c
Medium	1476.8b	1821.5b	3201.8b	1408.8b
Large	1805.3a	2206.1a	3878.5a	2079.2a
SE ±	56.23	49.18	50.36	61.74
Interactions				
P x V	NS	NS	NS	NS
V x S	NS	*	*	NS
S x P	NS	NS	NS	NS
P x V x S	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 5% probability.

* = Significant at 5% level of probability

NS = Not significant

Table 8. Interaction of seed size and variety on soybean leaf area (cm^2)/plant at 10 and 12 weeks after planting at Samaru, 1990 wet season.

	Weeks after planting			
	10		12	
Seed sizes	Samsoy-2	TGM-344	Samsoy-2	TGM-344
Small	1283.3d	1475.4c	2509.3d	2703.4c
Medium	1658.2c	2068.3b	2826.2c	3252.7b
Large	2217.1b	2558.1a	3247.5b	3612.3a
SE ±	62.02		60.45	

Means followed by the same letter(s) within a treatment group are not significantly different at 5% probability.

significantly different from those of medium seeds of Samsoy-2 and small seed of TGM-344 .

4.1.5 Leaf dry weight per plant

The soybean plants that were given 35 and 70kg P_2O_5 ha^{-1} had significantly greater leaf dry weight (gm) per plant than those that received 0kg P_2O_5 ha^{-1} throughout the sampling periods except at 10 WAP when the influence of P treatments on leaf dry weights were significantly different from the other. At 14 weeks after planting, the plants that received 35 and 70kg P_2O_5 ha^{-1} had significantly higher leaf dry weights than those from the control (Table 9).

The influence of variety was significant on leaf dry weight per plant throughout the sampling periods. Variety TGM-344 had higher leaf dry weight than Samsoy-2.

Large sized seeds produced plants with leaf dry weights per plant that were significantly greater than those of other seed sizes.

There was no significant interaction between the treatments on leaf dry weight per plant.

4.1.6 Total dry weight per plant

The total dry matter (gm) per plant was significantly affected by phosphorus levels. At 8 to 14 weeks after planting (WAP) the weights of plants supplied with 35 and 70kg P_2O_5 ha^{-1} were similar but were significantly higher than those with no phosphorus. At harvest, however, 35kg P_2O_5 ha^{-1} resulted in significantly higher plant weight than other P-rates while the plants given 70kg P_2O_5 ha^{-1} had higher dry weight than those of the control.

Table 9. Leaf dry weight of soybean (gm/plant) as influenced by phosphorus, variety and seed size at Samaru, 1990 wet season.

	Weeks after planting			
Treatments	8	10	12	14
Phosphorus levels.				
(Kg ha^{-1})				
0	4.4b	7.6c	10.9b	11.4b
35	5.8a	9.7b	13.7a	14.3a
70	6.4a	10.5a	14.5a	15.3a
SE ±	0.33	0.23	0.32	0.39
Varieties				
Samsoy-2	4.6a	8.3b	11.9b	12.6b
TGM-344	6.5a	10.3a	14.2a	14.7a
SE ±	0.28	0.21	0.27	0.28
Seed sizes				
Small	4.3c	7.9c	11.3c	11.2c
Medium	5.5b	9.4b	13.4b	13.6b
Large	6.8a	10.5a	14.8a	16.0a
SE ±	0.26	0.30	0.45	0.40
Interactions				
P x V	NS	NS	NS	NS
V x S	NS	NS	NS	NS
S x P	NS	NS	NS	NS
P x V x S	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 5% probability.

NS = Not significant at 5% level.

The varietal effect was significant on soybean dry weight throughout the sampling periods. The variety TGM-344 gave significantly greater dry weight per plant than Samsoy -2.

The effect of seed size on total dry weight was also significant. Up to harvest time, plants from large seeds produced significantly greater dry weight per plant compared to the other seed size treatments. Total dry weights from medium seeds were significantly higher than those from small seeds (Table 10).

No interaction of significance was observed on the dry weight per plant all through the sampling periods.

4.2 Effect of Phosphorus and Seed size on Yield and Yield Components of Two Cultivars of Soybean.

4.2.1 Number of flowers per plant

This agronomic character was significantly affected by phosphorus treatments throughout the sampling periods (Table 11). The application of phosphorus fertilizer enhanced flower production. Each increament in the level of applied phosphorus resulted in significant increase in the number of flowers per plant execpt at 6 weeks after planting (WAP) when the number of flowers produced at 0kg P_2O_5 ha $^{-1}$ was similar to that at 35kg P_2O_5 ha^{-1}.

The number of flowers produced by TGM-344 was significantly higher than that of Samsoy -2 throughout the sampling periods.

Table 10: Effect of phosphorus, variety and seed size on total dry weight (gm) / soybean plant at Samaru, 1990 wet season.

Treatments	Weeks after planting 8	12	14	harvest
Phosphorus levels				
(kg ha^{-1})				
0	11.0b	37.7b	51.8b	36.7c
35	13.2a	42.6a	54.8a	42.4a
70	12.8a	40.8a	53.7a	38.9b
SE±	0.48	0.75	0.53	0.47
Varieties				
Samsoy-2	9.8b	33.9b	45.1b	31.1b
TGM-344	14.8a	46.8a	61.7a	47.5a
SE±	0.45	0.46	0.64	0.52
Seed sizes				
Small	9.1c	37.6c	50.0c	36.3c
Medium	12.6b	40.3b	53.4b	39.0b
Large	15.3a	43.2a	56.9a	42.6a
SE±	0.47	0.52	0.64	0.71
Interactions				
P x V	NS	NS	NS	NS
V x S	NS	NS	NS	NS
S x P	NS	NS	NS	NS
P x V x S	NS	NS	NS	NS

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

NS = Not significant at 5% level.

Table 11. Influence of phosphorus, variety and seed size on the number of flowers / soybean plant at Samaru, 1990 wet season.

	Weeks after planting			
Treatment	6	8	10	12
Phosphorus levels ($Kg\ ha^{-1}$)				
0	15.0b	21.1c	24.1c	10.8c
35	16.0b	25.4b	28.3b	13.7b
70	20.0a	31.7a	33.0a	16.7a
SE±	0.63	0.75	0.50	0.58
Varieties				
Samasoy-2	13.6b	21.1b	22.9b	11.7b
TGM-344	20.0a	31.0a	34.0a	15.7a
SE±	0.69	0.61	0.25	0.35
Seed sizes				
Small	15.2b	25.5	27.9	13.0
Medium	17.2ab	26.4	28.9	14.1
Large	18.5a	26.2	28.6	13.9
SE±	0.77	0.73	0.41	0.47
Interactions				
P x V	*	NS	NS	NS
V x S	NS	NS	NS	NS
S x P	NS	NS	NS	NS
P x V x S	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 5% probability.

* = Significant at 5% level. NS = Not significant.

Seed size was of no effect on the number of flowers per plant except at 6 WAP when large seed size had significantly more flowers per plant than the small seed size but was at par with flowers produced from medium seed. Number of flowers per plant from small seed was also not significantly different from those of medium seed.

A significant inter action between phosphorus and soybean variety was observed at 6 WAP (Table 12). Application of phosphorus had no effect on the number of flowers per plant in TGM-344. For Samsoy-2, phosphorus fertilizer application at 70kg P_2O_5 ha^{-1} increased the number of flower per plant significantly compared with 35 or 0kg P_2O_5 ha^{-1}, but was not significantly different from those of TGM-344 that were given 0 and 35kg ha^{-1} of phosphorus.

4.2.2 Number of pods per plant

The phosphrous application significantly influenced the number of pods per plant. The plants supplied with 35kg P_2O_5 ha^{-1} produced significantly higher number of pods per plant throughout the sampling periods than the other P-rates. The number of pods per plant for 70kg P_2O_5 ha^{-1} was also significantly more than for the control treatment.

The cultivar TGM-344 yielded significanlt greater number of pods per plant than Samsoy-2 from 8 WAP up to time of harvest.

Table 12. Interactive influence of phosphorus and variety on the number of flowers/ soybean plant at 6 weeks after planting at Samaru, 1990 wet season

Phosphorus levels (kg ha^{-1})	Varieties	
	Samsoy-2	TGM-344
0	10.4c	19.5ab
35	12.1c	19.9ab
70	18.4b	21.7a
SE$\pm$	0.96	

Means followed by the same letter(s) within a treatment group are not significantly different at 5% probability.

The number of pods per plant produced from all seed sizes differed significantly from each other. The number of pods per plant increased as the seed size increased with the small seed size producing the least pods per plant throughout the sampling periods (Table 13)

There was no any significant interaction between phosphorus and seed size on the number of pods per soybean plant.

4.2.3 Number of days to 50% flowering

The effects of phosphorus, seed size and variety on the number of days to 50% flowering were presented in Table 14. Neither phosphorus nor seed size had any significant effect on the number of days to 50% flowering.

However cv. Samsoy-2 reached 50% flowering stage about eight (8) days earlier than the TGM-344 which was of significance.

No any significant interaction on time to 50% flowering was observed during this research project.

4.2.4. Number of lodged plants

The number of lodged plant per plot was greatest for the plants supplied with 35 and 70kg P_2O_5 ha^{-1} when compared to the control treatments all of which in turn had significantly higher lodging than those that receive no phosphorus (Table14).

The variety effect was however significant . The variety TGM-344 had significantly more lodged plants than Samsoy-2.

Table 13. Influence of phosphorus, variety and seed size on the number of pods / soybean plant at Samaru, 1990 wet season.

Treatments	Weeks after planting 8	12	14	At harvest
Phosphorus levels ($Kg\ ha^{-1}$)				
0	13.2c	52.1c	66.5c	74.5c
35	22.1a	69.7a	86.2a	100.5a
70	18.3b	63.5b	79.0b	94.3b
SE±	0.81	0.67	0.78	0.32
Varieties				
Samsoy-2	14.6b	54.4b	67.2b	72.8b
TGM-344	21.1a	69.2a	87.3a	109.4a
SE±	0.78	1.07	0.67	0.44
Seed sizes				
Small	11.1c	53.1c	69.0c	83.5c
Medium	17.6b	61.2b	76.6b	89.7b
Large	24.8a	71.1a	86.1a	100.1a
SE±	0.56	1.12	0.93	0.56
Interactions				
P x V	NS	NS	NS	NS
V x S	NS	NS	NS	NS
S x P	NS	NS	NS	NS
P x V x S	NS	NS	NS	NS

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

NS = Not significant at 5% level.

Table 14. Influence of phosphorus, variety seed size on the number of days to 50% flowering and number of lodged plants / plot at Samaru, 1990 wet season.

Treatments	Number of days to 50% flowering	Number of lodged plants/plot
Phosphorus levels (Kg ha^{-1})		
0	57.8	34.3b
35	58.2	63.0a
70	59.4	64.4a
SE±	0.56	0.59
Varieties		
Samsoy-2	54.3b	41.9b
TGM-344	61.9a	64.6a
SE ±	0.26	0.69
Sees sizes		
Small	57.6	52.8
Medium	58.2	54.7
Large	58.3	55.2
SE±	0.38	0.85
Interactions		
P x V	NS	*
V x S	NS	NS
S x P	NS	NS
P x V x S	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 5% probability.

NS = Not significant at 5% level of significance.

The effect of seed size on the number of lodged soybean plants per plot was however, insignificant.

The interactive effect of phosphorus and variety was significant. The TGM-344 plants supplied with 70kg ha^{-1} of phosphorus had significantly more lodged plant than all the other observations. However, there were insignificant differences amongst the Samsoy-2 plants given 35 and 70kg P_2O_5 ha^{-1} and those of TGM-344 treated with no phosphorus for the number of lodged plant. The least lodging was recorded for Samsoy-2 that received no phosphorus fertilizer (Table 15).

4.2.5 Number of seed per plant

The effect of phosphorus levels on the number of seeds per plant was significant (Table 16). Plants that received 35kg ha^{-1} of P_2O_5 produced significantly more seeds than the other P-treatments. Those given 70kg P_2O_5 ha^{-1} yielded significanly greater number of seeds per plant than the no phosphorus control plants.

The variety TGM-344 produced significantly more seed per plant compared with Samsoy-2. TGM-344 plants had significantly greater number of seeds than Samsoy-2.

The number of seeds per plant also increased significantly with increase in seed size. Plants from large seeds produced more seeds than other seed sorts.

No interaction was significant on this agronomic character.

Table 15. Interactive influence of phosphorus and variety on number of lodged plants/plot at Samaru, 1990 wet season.

Phosphorus levels (kg ha^{-1})	Varieties	
	Samsoy-2	TGM-344
0	27.6e	48.1cd
35	47.8cd	66.5b
70	50.7c	70.2a
SE±	1.03	

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

Table 16. Number of seeds/plant, 100-seed weight and grain yield ($kg\ ha^{-1}$) as influenced by phosphorus, seed size and soybean variety at harvest at Samaru , 1990 wet season.

Treatments	Number of seeds/plant	100-seed weight(gm)	Grain yield ($Kg\ ha^{-1}$)
Phosphorus levels			
($Kg\ ha^{-1}$)			
0	223.9c	14.1c	1258.2c
35	292.7a	14.9a	1465.7a
70	271.2b	14.5b	1359.8b
SE±	0.84	0.08	20.55
Varieties			
Samsoy-2	243.9b	15.3a	1541.6a
TGM-344	281.3a	13.4b	1178.8b
SE±	1.16	0.10	22.43
Seed sizes			
Small	239.3c	13.9c	1294.7c
Medium	259.2b	14.4b	1366.3b
Large	289.3a	14.8a	1430.1a
SE±	1.98	0.10	17.67
Interactions			
P x V	NS	NS	NS
V x S	NS	NS	NS
S x P	NS	NS	NS
P x V x S	NS	NS	NS

Means followed by the same letter(s) within each treatment group are not significantly different at 5% probability. NS = Not significant at 5% level.

4.2.6. 100-seed weight (gm)

Individual seeds of plants supplied with 35kg ha^{-1} of P_2O_5 were statistically heavier than those supplied with either 70kg ha^{-1} of P_2O_5 or no-phosphorus treatment (Table 16). 100-seed weights of plots given 70kg P_2O_5 ha^{-1} were significantly greater than those of the control.

The 100-seed weight of variety Samsoy-2 was significantly greater than that of TGM-344 cultivar.

Seed size also had an effect on 100-seed weight which increased significantly as seed size increased with the small size producing the least 100-seed weight.

None of the interactions was significant on 100-seed weights.

4.2.7. Grain yield.

Grain yield per hectare of soybean was significantly affected by phosphorus application. The highest grain yield was obtained from 35kg ha^{-1} of P_2O_5 which was significantly greater than that of either 0 or 70kg P_2O_5 ha^{-1}. The 70kg P_2O_5 ha^{-1} treatment in turn resulted in significantly higher yield than the no-phosphorus control. Samsoy-2 cultivar out yielded TGM-344by about 13.5% of the total grain yield (Table 16).

Seed size also had a significant influence on grain yield. Large seed produced the greatest yield that was significantly different from that obtained from medium seed which was also significantly higher than that of the small seed.

The interaction was not significant on grain yield.

4.3 Correlation

The grain yield, growth characteristics and yield components of soybean were subjected to coefficient of correlation to determine the relationships between the various characters.

Growth characters such as plant height (cm) at 6 weeks after planting (WAP), numbers of branches (at 14 WAP) and nodes (at 14 WAP) per plant had high and positive significant correlations with the soybean grain yield at harvest (Table 17). The seed yield was also positively and highly correlated to number of flower per plant (at 6 WAP) and number of pods per plant (at 14 WAP).

There was positive significant correlation of grain yield (Kg ha^{-1}) at harvest with 100-seed weight and leaf dry weight per plant (at 8 WAP). The number of seeds per plant showed insignificant but positive correlation to grain yield.

A negative and highly significant correlation was observed for seed yield with dry matter (gm) per plant at harvest. The leaf area (cm) per plant (at 12 WAP) was also negatively but insignificantly correlated to the grain yield per hectare.

Table 17. Matrix of Coeffic :nts of Correlation(r) between the Growth, Yield and Yield Components of Soybean cultivars SAMSOY-2 and TGM 344 at Samaru, 1990 wet season.

	1	2	3	4	5	6	7	8	9	10	11
1.	1										
2.	0.75**	1									
3.	0.73**	0.97**	1								
4.	0.83**	0.77**	-0.74**	1							
5.	-0.19	-0.08	0.50**	0.20	1						
6.	0.28*	0.06	0.26*	0.31**	0.90**	1					
7.	-0.37**	0.75**	0.72**	-0.42**	0.42**	0.39**	1				
8.	0.60**	0.92**	0.89**	0.64**	-0.27*	-0.14	-0.84**	1			
9.	0.30**	0.15	0.14	0.28*	-0.67**	0.59**	0.57**	0.42**	1		
10.	0.13	0.32**	0.32**	0.31**	0.34**	0.20	0.55**	0.44**	0.53**	1	
11.	0.24*	-0.61**	0.62**	-0.18	0.66**	0.46**	0.89**	-0.81**	0.86**	0.62**	1

KEY: *= Significant at 5% probability (i.e. all values above 0.232).
**= Significant at 1% probability (i.e. all values above 0.303).
DF= 70.

1. Grain yield (Kg ha^{-1})
2. Plant height(cm) at 6 WAP
3. Number of branches/plant at 14 WAP.
4. Number of nodes/plant at 14 WAP.
5. Leaf area (cm^2)/plant at 12 WAP.
6. Leaf dry weight(gm)/plant at 8 WAP.
7. Dry weight(gm)/plant at 12 WAP
8. Number of flowers/plant at 6 WAP
9. Number of pods/plant at 14 WAP
10. Number of seeds/plant
11. One-hundred-seed weight(gm)

WAP = Weeks after planting.

CHAPTER 5

DISCUSSION

5.1 Effect of Phosphorus Level on Soybean

5.1.1 Growth of the plant

The results obtained from this study showed that plant height, number of nodes per plant , leaf area per plant , leaf area per plant, leaf dry weight per plant and total dry matter per plant increased with increasing level of applied P.

The significant increase in the height of soybean plant as phosphorus level increases is expected. The soil of the experimental farm was acidic and low in extractable phosphorus content (Appendix 1) . Thus any judicious P-application of up to 50 ppm (part per million) according to Zakaria *et al.* (1977) would stimulate optimum growth.

After absorption of phosphorus from the soil by soybean roots, it may eventually get to the shoot apex to stimulate rapid mitotic cell divisions in the meristem . This will cause a rapid elongation of second internode below the upper-most leaf in the shoot apex to generate the increase in plant height as observed in this project (Umekazi and Matsumoto, 1989).

A similar observation was made earlier on height of soybean at Samaru, Nigeria, with increasing phosphorus rate (Yev, 1990). In Brazil, the varieties UFV-2 and Cristalina showed increases in heights with applied phosphorus (Vieira *et al.*, 1986). This result also tallies with Chiezey's (1990) that soybean height increased with increasing amount of P applied to the soil.

The insignificant effect of P on the number of branches per plant agrees withYev's (1990) finding that number of branches per plant and a few other agronomic characters did not show any significant difference or response to P application. Shibles *et al.* (1976) cited that branches production was under genetic influence.

The number of nodes per plant was significantly affected by phosphorus. This conforms with Donahue (1977) who reported similar trend because of increase in height and internodal lenght of the shoot in plants.

The significant increase in leaf area per plant due to P-level could be attributed to the effect of phosphorus in stimulating the formation of new leaves in plants as Sanchez *et al.* (1976) reported for strawberry plant. This nutrient generally promoted plant growth and thus the leaves, (Dutta, 1974). The increase in leaf area could provide larger or wider surface area for better interception of sun light for efficient photosynthesis, consequently promoting plant growth.

The leaf dry weight per plant showed significant increase with P level, because according to Norman (1963) soybean leaves, particularly those on the lower part serve as storage for excess phosphorus in the shoot from where it could be mobilised to other parts of the plant when required.

Therefore the more phosphorus applied to a crop of soybean the more it will accumulate in the leaves thereby increasing their weights. This tallies with the findings of Caldwell (1973) that increasing phosphorus level increased the weights of leaves, stems and pods as well as grain yield of soybeans.

The total dry weight per soybean plant increased significantly with increaseing phosphorus level. This corroborates with Mahajan *et al.* (1982) that dry matter yield and phosphorus uptake increased with increasing level of the $P_2 0_5$, from 0 to 90gk ha^{-1}. Lauer and Blevins (1989a) also found that dry matter accumulation of soybean increased significantly with P in hydroponic culture. The increase in plant height and leaf area per plant may have increased the light interception by the foliage of the plant which could increase photosynthates production and consequently increase the growth of various plant parts.

5.1.2 Yield and yield components

There was a significant increase in the number of flower per plant with increasing phosphorus treatment which could be due to the influence of the nutrient element on the growth of the various plant parts. Lauer and Blevins (1989b) also reported increased flowering as well as pod production and abortion in soybean due to increased P-level.

The nutrient also affected the number of pods per plant which increased significantly with the level of applied P. This corroborates with the observations of Lauer and Blevins (1989b) that increasing level of P increased pod production by soybean, pod weight also increased with increasing P level, (Caldwell, 1973). Donahue (1977) found similar increase in number of pods per plant in *Arachis hypogeae*, L.

The insignificant effect of phosphorus on number of days to 50% flowering may be due to some environmental factors (Vines and Rees, 1972) since earlier records on some varieties at the same location indicated that increased phosphorus delayed blooming (Yev, 1990). However the soybean plants supplied with the highest dose of phosphorus (i.e. 70 kg P_2O_5 ha^{-1}) required more time to flower compared with those given lower P- levels.

Lodging per plot was found to be affected by phosphorus in this trial. It increases with increasing P -rate. This conforms with Bharati (1986) who discovered that increasing phosphorus level caused increased lodging in soybean consequently leading to severe grain yield loses.

This may be because phosphorus nutrient enhanced plant height and tall plant are more susceptible to lodging due to the effect of wind.

The number of seeds per plant increased with increase in phosphorus to a certain level. Seeds are the most important economic sinks of soybean. Therefore during their development most of the nutrients in plants are translocated to these sinks to supply the developing embryos. This ultimately resulted in a general decrease in nutrients content and weights of the other plant parts. But the phosphorus contents in most of these parts fell during seed development (Norman, 1963).

Increasing P-level influenced the 100-seed weight and the total grain yield per hectare. This agrees with the report of Olufajo (1987) on soybean at the same location that increase in soybean grain yield was due to applied phosphorus. Yuan *et al.* (1979) and Lauer and Blevins (1989b) found similar effects.

5.2 Effect of Variety

5.2.1 Growth of soybean

The two varieties used in this experiment exhibited significant differences in the various growth parameters assessed. Plants of TGM-344 had greater leaf area , leaf dry weight, number of nodes per plant, plant height and dry weight per plant than cultivar Samsoy-2 . On the other hand Samsoy-2 had more branches per plant than TGM-344.

The variations in some of these growth characteristics could be attributed more to the genetic make up of these cultivars. The numbers of nodes and branches, leaf appearance and arrangements are genetically controlled although temperature has a strong influence on these features. The number of nodes, branches, leaf appearance and arrangements are genetically controlled although temperature has a strong influence on these parameters (Shibles *el al.* 1976).

5.2.2 Yield and yield components

Variety Samsoy-2 out yielded TGM-344 by about 13.5% . Many factors may have contributed to this. One paramount factor could be the better adaptability of Samsoy-2 to Samaru environment than TGM-344. Another reason is the degree of lodging observed for TGM-344 was significantly higher than that of Samsoy-2. Wood and Swearing (1977) reported decreased seed yield whenever lodging occurred especially prior to physiological maturity. And Samsoy-2 had higher 100-seed weight.

TGM-344 cultivar had significantly more flowers, pods and seeds per plant but lower 100-seed weight and bloomed later than Samsoy-2. It also lodged more than the variety Samsoy-2 which could be responsible for its lower grain yield (per hectare).

5.3 Effect of Seed Size on Soybean

5.3.1 Growth of the plant

Seed size greatly influenced soybean performance . The height of plant increased with increase in the size of soybean seed. This could be due to greater seedling vigour produced from large seeds after germination. Large seeds could contain large embryos and their large cotyledons might have contributed more nutrients to the seedlings during the early growth period for better stem growth and development since the contributions of the cotyledons to total seed weight of soybean, according to Laddha and Gupta (1977), increased with increasing seed size. This could result in taller plants. This view is supported by the investigations of Whitehead *et al.* (1980) and Singh *et al.* (1980).

More branches per plant resulted from plants of large seeds which differed significantly from those of other seed grades. This is possible since large seeds influenced rank growth because their dense cotyledons could contribute more nutrients to the seedlings during the early growth stages than smaller seed sizes. It has also been reported that seedling growth rate was partly determined by the genetic constitution of the seed (Fontes and Ohlrogge, 1972; Caldwell, 1973 and Whitehead 1980).

The observed number of nodes per soybean plant increased with the seed size factor which could be related to seed size influence on the plant height . Lee *et al.* (1989) also discovered that seed weight was positively correlated with node number, leaf number and stem length.

Leaf area and leaf dry weight per plant increased with increasing seed size. Large seeds produced plants having greater leaf area per plant than those from smaller sizes. This tallies with the previous findings for soybean (Burris *et al.*1973), for subterranean clover (Black, 1956) and for

Phaseolus sp. (Chin, 1977). Dry matter of leaves from large seed size was also greater than those from smaller seed sizes. This observation could also be due to the fact that plants from large seeds are more vigorous right from the early growth periods. They have initial advantages over seedlings from smaller seed sizes. This initial advantage was maintained till harvest.

Considering the effect of seed size on dry matter per plant, large seeds gave plants that were statistically heavier than other seed sizes. Teixeira and Costa (1989) also found that the dry weights of roots and shoots of soybean increased with increasing seed size . This could be because large seed produced rank plant with large leaf area and weight which could increase the total dry matter per plant because of the higher rate of photosynthesis compared to plants from small and medium seeds.

5.3.2 Yield and yield components

The number of flowers per plant was not affected by seed size. Plants from all seed categories produced similar number of flowers per plant all through the reproductive stages of the varieties Samsoy-2 and TGM-344. This complies with the observations of Musa (1990) in which seed size had no significant effect on numbers of flowers per plant and days to 50% flowering in cowpea.

Large seeds had significantly higher number of pods per plant than medium and small seed lots. This is in accordance with Carelli and Fahl (1979) who reported greater numbers of pods and seeds per plant as well as increased dry weight of soybean plants from large seeds than those from small seeds. Similar report was also made for rape plant by Major (1977).

There was no significant effect of seed size on number of days to 50% flowering of soybean in this trial.This is in agreement with Musa (1990) who also expressed the same result in cowpea. This may be because the onset of flowering in some plants is known to be under the influence of external conditions like day-lenght (ie photoperiodism) and temperature (vernalization) through hormone activity, (Vines and Rees, 1972).

Soybean lodging was not affected by seed size although the number of lodged plants per plot was insignificantly greater for large seeds compared with smaller seed sizes. This agrees with the findings of Smith and Camper Jr. (1975) who discovered that seed size had little or no significant effect on plant stands, maturity, lodging and mean size of harvested soybean seeds.

As for the number of seeds per plant, large seeds produced plants with more seeds per plant than other sizes of seeds which is in conformity with findings of Carelli and Fahl (1979).

Plants from large seeds gave more of some crucial yield components for instance pods and seeds per plant mainly due to their more vigorous growth than smaller seed sizes. The fact that large seeded plant had significantly more number of flowers per plant might ultimately lead to more pod production since the pods develop from the flowers and consequently more seeds which also develop in the pods.

The effect of seed size on one-hundred-seed weight was found to be significant. Large seed produced heavier seeds which were, however, not significantly different from those of medium seed but both were significantly different from those of small seeds. Earlier, some researchers indicated similar findings in soybean. It was also observed that weights of seed interguments, embryonic axis and cotyledons increased with increasing seed size. This could be because of the dense food storage and large embryo produced from plant of large seed size (Singh *et al.* 1980 ; Teixeira and Costa 1989).

In terms of grain yield (per hectare), soybean plants from large seeds performed better than other seed grades, viz small and medium sizes. From the results plants from large seeds out yielded those from either medium or small seeds by more than 4%. Plants from large seed had more yield components which would result in higher yield. The same trend was reported by Smith and Camper Jr. (1975) and also in other crops like wheat (Hamptom,1981) and cowpea (Sahabi,1988).

5.4. Influence of Interactions

5.4.1 Phosphorus (P) versus soybean variety (V)

A significant phosphorus and variety interaction was observed on the number of nodes per plant at 10 weeks after planting (WAP) . Applying phosphorus at the rate of 35kg P_2O_5 ha^{-1} significantly affected number of nodes per plant on TGM-344 variety by producing significantly more nodes than all the other treatments. This could be because of the varietal differences in reacting to phosphorus application which complies with the observations of Vieira *et al.* (1986) that cv. Cristalina showed more vigorous growth than UFV-2 to increasing levels of P_2O_5.

At 6 weeks after planting (WAP) phosphorus and variety interaction on the number of flowers per plant was significant.

Although cultivar TGM-344 had significantly more flowers per plant with increasing phosphorus level, Samsoy-2 at 70kg P_2O_5 ha^{-1} gave statistically as much flowers as TGM -344 given no P. This result corroborates with that of Lauer and Blevins (1989b) who found that increasing P level increases flowering on cv. William - 82 in hydroponic culture. Musa (1990) also made similar observation in cowpea.

A significant interactive effect of phosphorus and variety on the number of lodged soybean plants per plot was recorded, with the variety TGM-344 having the highest number of lodged plant per plot, of the two varieties. According to Bharati *et al.* (1986) and Norman (19780) this could be due to the effect of increasing P-levels that stimulated increasesd soybean height, growth vigour and more leaf phosphorus all of which may encourage lodging by wind.

5.4.2 Seed size (S) against variety (V)

The interaction of seed size and variety on leaf area per plant was significant at 10 and 12 WAP. The cultivar TGM-344 which produced significantly large leaf area than all the other treatments at both periods of sampling could be due to its vigorous growth response to increasing seed size. This tallies with the report of Mohammed *et al.* (1988) in which soybean cv.s William, Lee and Clark-63 exhibited significant seed size and soybean variety interaction on various characters. Teixeira and Costa (1989) also noted shoot weight increase with increase in seed size.

5.4.3 Seed size (S) and phosphorus (P)

Significant interaction between phosphorus and seed size was recorded on soybean plant height at harvest. Both phosphorus and seed size produced significant increase in plant height. Vieira *et al.* (1986) found that increasing P-level on some soybeans caused an increase in height and other characters while Burris *et al.*(1973) also recorded increase in plant height with increasing size of soybean seeds.

5.4.4 Phosphrous (P) x variety (V) x seed size (S)

There was significant interactive effect of phosphorus, variety and seed size on plant height at 10 WAP. Large seed of TMG- 344 supplied with 35kg ha^{-1} of $P_2 O_5$ had statistically greater height than other treatments. It shows that the TGM -344 variety was more responsive to the combined effects of phosphorus and seed size treatments on plant height than the cultivar Samsoy-2.

5.5 Correlation

Soybean leaf dry weight (at 8 WAP), plant height (at 6 WAP), number of branches (14WAP), number of nodes (14WAP) and number of pods (14 WAP) per plant showed highly significant and positive correlations with the grain yield of soybean. These growth and yield characteristics are very important in the contribution of photosynthates and useful nutrients, for the development of seeds at physiological maturity, i.e. by mobilisation of materials to the sinks. This is in conformity with the findings of Shibles *et al.*(1976) for soybean and Black (1956) for *Trifolium subterraniem*, L.

Some agronomic characters like dry weight per plant (at 12 WAP) and leaf area per plant (at 12 WAP) had significant and negative correlations to grain yield because at this period of sampling the shoots were almost dry . This confirms the finding of Norman (1963) who reported that the tops of soybean fell drastically at pod filling and seed development stages.

One-hundred-seed weight and leaf dry weight per plant (at 8 WAP) had significant positive correlation with grain yield. The one-hundred-seed weight could directly contribute to grain yield while the leaf dry weight could be by indirect contribution.

CHAPTER 6.

SUMMARY AND CONCLUSION

This study was conducted at the experimental farms of the Institute for Agricultural Research, Samaru, Ahmadu Bello University, Zaria, Nigeria, during the wet season of 1990 to investigate the influence of phosphorus level and seed size on growth, yield and yield components of two soybean, *Glycine max* (L), Merrill, varieties.

The treatment were made up of two cultivars (Samsoy-2 and TMG - 344), three phosphorus levels (0,35 and 70kg P_2O_5 ha^{-1}) and three seed sizes (small, medium and large). These were laid out in a split - plot design with four replications in which phosphorus level and variety were the main plot and seed size was the sub plot.

Phosphorus increased the plant height, numbers of branches and nodes, leaf area, leaf dry weight, total dry weight per plant, lodging, numbers of flowers, pods, and seeds per plant, time to 50% flowering as well as 100-seed weight. Grain yield also increased with increasing P-level.

Growth characters for instance plant height, number of branches, number of nodes, leaf area, leaf dry weight and total dry weight per plant were significantly affected by seed size. Seed size affected grain yield and some yield components like numbers of pods and seeds per plant and 100-seed weight in which plants from large soybean seeds produced significantly more of these characters than those from medium and small seeds. But seed size had insignificant influence on lodging.

TGM-344 cultivar had higher lodging, plant height and a few other agronomic characters. However Samsoy-2 produced more grains per hectare, flowered earlier and had heavier seeds than TGM-344 which also had higher numbers of flowers, pods and seeds per plant than Samsoy-2.

In terms of the interactions of phosphorus with variety, TGM-344 supplied with 35kg P_2O_5 ha^{-1} had significantly more nodes, flowers per plant and lodged more than Samsoy-2 which in turn lodged less with increasing level of phosphorus.

The significant interactive effects of seed size and variety demonstrated that seed size affected leaf area (cm^2) per plant of soybean. The variety TGM-344 from large seed gave significantly more of this agronomic characteristic than all other treatments.

A significant interaction of seed size and phosphorus was observed on the soybean plant height at harvest. The combined effects of these interacting treatments were more pronounced with the increase in magnitude of the treatments.

P x V x S interaction was significant on plant height at 10 weeks after planting (WAP) when the large seed of TGM-344 variety produced significantly taller plants than all other treatments at 35kg ha^{-1} of applied P_2O_5.

A positive correlation was established between grain yield and plant height, number of branches, number of nodes per plant, leaf dry weight , numbers of flowers and pods per plant and 100-seed weight. The total dry weight and leaf area per plant (at 12 WAP) showed negetive correlations to grain yield.

From this research, it could therefore be concluded that phosphorus at the rate of 35kg P_2O_5 ha^{-1} is optimum for better performance of these varieties of soybean in Samaru area. Farmers should also endeavour to sort out their seeds before planting since large seeds may improve their grain yield. The cultivar Samsoy-2 should be extensively introduced to farmers in this part of Northern Guinea Savanna of Nigeria for better yield.

Although Samsoy-2 variety performed better, TGM 344 showed some promising agronomic qualities which could be improved upon for better grain yield. Lodging could be minimised by planting trees as wind breakers around the farm or by supply of nutrients like Ca, K, N, etc that could strengthen the stem of the variety.

REFERENCES

Adepetu, J. A. and Akapa, L.K. (1977).' Root growth and nutrient uptake characteristics of some cowpea varieties'. *AgronomyJournal, 69* ; 940.

Afolabi, N. O. and Osiname, O. A. (1980). 'Effect of phosphorus on soybean yield in south-western Nigeria'. World soybean research conference II, West view press, I.A.R. & T,Moor Plantation, Nigeria.

Aku, S.Y. (1988). 'An address at the annual conference of the Nigeria Soybean Association'. In *Proceedings of the 8th Annual SoybeanComference.* Ogunbodede, B.A. and Ortese, J.T. (ed). Pp. 5 - 20.

Ala, A.Y., Kuzin, V.F. and Alesksenke, B.I. (1980). ' The Origin of Soybean (a review)' . *(Soybean Abstracts, 3*(1) , Abstr. 1; 1980).

Allison, L.E. (1965). ' Organic Carbon' . Black , C.A. (Ed). *Method of Soil Analysis.* pp. 1367 - 1378. *American Society of Agronomists,* Madison.

Anonymous. (1978).' Soybean Digest Blue Book' . *American Soybean Association,* Hudson, U.S.A. 16.

Anonymous. (1983). ' International Institute of Tropica Agriculture - IITA , Research Briefs'. KLM publications - Handling Service, Schiphol, Holand. (1, 2 & 3) : 6pp.

Anonymous. (1985). 'Soybean in Nigerian Diet' . Extension Bulletin No. 21, Agricultireal Extension and Research Liaison Service, Institute for Agricultural Resaerch, Ahmad Bello University, Zaria, Nigeria, 1pp.

Anonymous. (1988).' Production - FAO Year Book'. FAO United Nations, Rome. Italy. *42;* 155pp.

Anonymous. (1991). *Hints* Magazine. True Tale publication plc. ISSN 5795 - 512x *3* (21) Lagos, Nigeria. Back cover page, July, 1991.

Appelquist, L.A. (1978). 'Relationship between the use of fertilizers and the production of Lipids'. *Ferilizer use and production of carbohydrates*, Sweden; 257 - 267.

Bamgbose, A.A.A., Tewe, O.O. and Weingartner, K. (1989). 'Nutritional values of some plant protein concentrates in Nigeria; 1. Protein Quality'. Tropical Grains Legumes Bulletin No. 36, 15pp.

Barber, S.A. (1978). 'Growth and Nutrient uptake by roots of soybean under field condition'. *Agronomy Journal, 70* (3) : 457 - 461.

Barber, S. A. (1980) . ' Twenty-five years of phosphorus and potassium fertilization of a crop rotation'. *Fertilizer Research, 1* (1) : 29 - 36

Beveridge, J.L. and Wilsie , C.P. (1959). ' Influence of depth of planting, seed size and variety on emergence and seedling vigour of Alfalfa'. *Agronomy Journal, 51*; 731-734

Bhangoo, N.S. and Albritton, D.J. (1972) .'Effect of fertilizers N.P.K. on yield and nutrient content of lee soybean'. *Agronomy Journal. 64* (6): 743 -74.

Bharati, M.P., Whigham, D.K. and Voss, R.D. (1986).' Soybean Response to Tillage and Nitrogen, Phosphorus and potassium Fertilization'. *Agronomy Journal 78* (6); 947 - 950.

Bichi, S.I. (1982).'Position (past, present and future) of soybean among the oil crops in Nigeria'. In *proceedings of the second national meeting of the Nigerian soybean scientists, Publication* (2); PP. 40.

Black, J.N. (1956).'The Influence of seed size and depth of sowing on Pre-emergence and early vegetative growth of subterranean clever (*Trifolium subterraniem, L.)'. Australia Journal of Agricultural Research, 7* ; 98 - 108.

Bray, R.H. and Kurtz, L.T. (1945).'Determination of total organic and available forms of phosphorus in soils'. *Soil Science, 59*; 39 - 45pp.

Bremmer, J.M. (1965). Total Nitrogen; In *Methods of Soil Analysis* edited by C.A. Black. *Agronomy, 2 . American Society of Agronomist. Madison Wisconsin : 1149 - 1178.*

Burnett, R.S. (1951).'Soybean protein food products'. In Markley, K.S. (ed). *Soybean & Soybean products.* pp. 949 - 1051 . Interscience publishers, Inc. New York, USA., II.

Burris, J.S., Edje, O.T. and Wahab, A.H. (1973). 'Effect of seed size on seedling performance in soybeans; 2. seedling growth and photosynthesis and field performance'. *Crop Science 13*; 207.

Caldwell, B.E. (1973). 'Soybean - Improvement, production and uses'. *Agronomy Series* (16). American Society of Agronomy , Inc., USA. pp. 174 - 218.

Cassman, K.G., Whitney, A.S. and Stockenger, K.R. (1980).'Root growth and Dry matter Distribution of soybean as affected by phosphorus stress, nodulation and nitrogen sources'. *Crop Science, 20* (2) ;239.

Carelli, N. L. C. and Fahl, J.I. (1979). 'Influence of seed size on growth and yield of soybean plant'. *Bragantia ,38* (1) Brazil; 11-14. (*Soybean Abstracts, 4*(12). Abstr. 3811;1981).

Chapman, H.O. (1965). Cation exchange capacity. In *Methods of soil Analysis*, ed. by C.A Black. *Agronomy 9.* American Societyof Agronomists, Madison, Wisconsin. pp. 891 - 901.

Chapman, S.R. and Carter, L.P. (1976). *Crop production: Principles and practice.* W.H.Freeman and Company, San Francisco, U.S.A., 95 - 122pp.

Cheng, J.H. and Cheng, F.I. (1986). 'Effect of phosphorus fertilizer on the soybean in different types of soil'. *Taiwan Agricural Bimonthly, 22*(1):28 - 34. (*Field Crop Abstracts.* Abstr. 4535. 41 (7). 1988).

Chiezey, U.F. (1990). 'Effect of plant density and phosphorus on the yield & Y. components of soybean (*Glycine max* (L). Merrill)'. Unpublished Ph.D.Thesis, Dept. of Agronomy, A.B.U., Zaria, 11: 79 & 82pp.

Chin, H.F. (1977). 'Influence of seed quality on plant growth and development'. *Seed Technology in the Tropics,* University Pertemian, Malaysia; 75 - 83.

Clegg, C. (1980). *Biology for schools and colleges*. 2nd ed. Heinemann Educational Books,Ltd., London. 133pp.

Cooke, G.W. (1975). *Fertilizer for maximum yield*, 2nd (ed.) BLBS. Fletcher and Sons, Ltd, Norwich. 13, 140, 160 and 192pp.

Costa, N.D.D. and Sfredo. G.J. (1980). 'Effect of levels of phosphorus fertilizers and method of application on germination of seeds of cv . Parana'. Contro Nacional de pesquisa de soja; 54 - 55 (*Soybean Abstracts, 4* (9). Abstr. 1442; 1980).

Cure, J.D., Ruftey Jr., T.W. and Israel,D..W. (1988).'Phosphorus stress effects on growth and seed yield, Responses of Non-nodulated soybean to Elevated carbon dioxide; *Agron. Journ., 80* (6): 8.

Day, P.R. (1965). 'Particle fractionation and particle size analysis'. In *Methods of* Soil Analysis'. ed by C.A. Black. *Agronomy, 9.American Society of Agronomists,* Madison, W i sconsin, 545 - 567.

Delorit, R.J., Greub, L.J. and Ahlgren H.L. (1974). *Crop Production*. 4th ed. Prentice Hall, U.S.A., 406 pp.

Deregowda, A.G. and Jain. A.K. (1990). ' Alternative to fish meal'.*Animal Nutrition Highlights. American Soybean Association*, Madrid, Spain.

Dinakin, J. (1986). 'Soybean (*Glycine max*, L., Merr): Its Ecological Adaptation in Nigeria.'In *Proceedings of the 6th. Annual Workshop of the Nigeria Soybean Scientists on Nationaly Co-ordinated Reasearce of Soybean,* I AR & T. Moor Plantation,Ibadan, Nigeria, pp. 41.

Donahue, R.L. (1977). *Soil - An introduction to soil and plant growth.* 4th ed. prentice - Hall, Inc. Englewood cliff, New Jersey, 131 - 135pp.

Duncan, D.B. (1955). ' Multiple range and multiple F-test'. *Biometrics II,* 1.42.

Dutta, A.C. (1974) . *Botany - for degree students* 4th [illegible] University[illegible]

Egba, G.(1990).'Soybean contains elements that prevent cancer' In *The Voice Newspaper*. Benue printing and publishing corporation, Makurdi, Nigeria. 2 (2666). Front page.

Egli, D.B.,Leggette, J.E. and Wood , M.J. (1978). 'Influence of soybean seed size and position on rates and Duration of filling; *Agron. Journ.*, 70 (1); 127 - 130.

Evans, L.T. (1976). *Crop physiology - some case histories*. Cambridge University press, Cambridge, 327 - 357pp.

Ewer, D.W. and Hall, J.B. (1978). *Ecolog ical Biology 2. The Interrelations of Organisms*. Longman Group Ltd. London, 290pp.

Fontes, L.A.N. and Ohlrogge, A.J. (1972). 'Effect of Interplant competition; Influence of seed size and population on other characteristics of soybean'. *Agron. Journ. 64* (6); 833.

Fordhan, D.C. and Lundborg, G. (1991). A soybean Network for African? *African - Farming and food pressessing*. Alain Charles publishing Ltd., London, U.K., 5pp.

Gelmond, H. (1978). 'Problems of Crop and Germination'. In Gupta, U.S. (ed) *Crop Physiology*; pp.30 Oxford and IBH Publishing Co. New Delhi, India.

Goldsworthy, R.R. and Heatheote, R. (1964) 'Fertilizer trial with soybean in Northern Nigerian'. *The Empire Journal of Experimental Agriculture, 32*: 257 - 262.

Gonzalez Nava, D.F. and Velasquez Silva, J.N. (1987). Effect of phosphorus on yield of soybean ',. Labores de la seccion de agronomia: 50 - 53. (*Soybean abstracts,17*(5). Abst. 1604; 1990).

Guiar, P.A.A. (1979). 'Effect of seed size on germination and vigour of soybean (*Glycine max*, L., Merrill).' Anaia 2 Seminaria nacional de pesquisa de Soja ; 325 - 332. (*Soybean Abstracts, 4* (1). Abst. 96; 1981).

Hallmark, W.B. and Barber, S.A. (1981).'Phosphorus and potassium effects on soybean root growth and nutrient contents'.*American Society of Agronomy*, U.S.A.,178.

Hallmark , W.B. and Barber , S.A. (1984).'Root Growth and Morphology, Nutrient uptake and Nutrient status of Early Growth of Soybean as affected by Soil Phosphorus and Potassium'. *Agron. Journ.*,*76* (20) ; 209 - 210.

Hampaih, R. and Sinha, M.N. (1980). ' Studies on the effect of phosphorus on grain and green fodder yields of soybean. ' *Haryana Agricultural University Jou rnal Research, 2* (4) ; 308 - 311.

Hampton, J.G. (1981). 'The extent and significance of seed size variation in New Zealand wheat.' *New Zealand Journal of Experimental Agriculture,9*(2): 179 - 183.

Haque, I., Walker, W.M. and Funnah, S.M. (1980).'Effect of phosphorus and zinc on soybean in Sierra Leone'., *Commnuication in Soil Science and Plant Analysis, 11* (11): 1029- 1040.

Haskins, P.A. and Gorz, H.J. (1975). ' Influence of seed size, planting depth and companion crop on emergence and vigour of seedling in sweet clover'. *Agron. Journ. 67*; 652.

Inouye, J. and Jin,I.D. (1981). 'Studies on Seedling Emergence in CropPlants,Seed size and Elongation force of soybean seedling.' *Japanese Journal of Crop Science, 50* (3) : 344 - 840.

Israel, D.W.,(1987). 'Investigation of the Rate of Phosphorus in Symbiotic Dinitrogen Fixation'.*Plant Physiology, 84*(3): 835 - 840.

Janick, J., Schevy, R.W., Wood, F.W.,Ruttan, V.W.(1974). *'Plant Science -An introduction to world of crops*; 2nd, Ed.W.H. Freeman & Co. San Franscisco, U.S.A . 317 pp.

Joanna, F., Egli, D.B. and Legette, J.E. (1982). Pod and seed development in soybean cultivars with differences in seed sizes. *Agronomy Journal , 74* (1): 81 - 84.

Jones, G.D., Blutz, J.A. and Smith,T.J. (1988). 'Effect of phosphorus and potassium on soybean nodules and seed yield'. *Agronomy Journal, 69*: 1003.

Kowande, R.M., Ugale, S.D. and Patil, R.B. (1988). 'Influence of seed size on growth, yield and yield components of peal millet'. *Seed* Research, 16(2) : 222 - 225.

Komolafe, M.F., Adegbola, A.A., Are, L.A. and Ashye, T.I. (1980). *Agricultural Science for West African Schools and Colleges.* 2nd edition. University Press, Ltd. Ibadan. Nigerian, 30pp.

Kowal, J.M. and Knabe, D.T. (1972). *An Agroclimatological Atlas of NorthernStates of Nigeria* Ahmadu Bello University (ABU Press), Samaru, Zaria,Nigeria, 2 - 10pp.

Kumar, V. and Singh, M. (1981). 'Interaction of S,P. & Md inrelation to uptake and utilization of P by soybean'. *Soil Science , 129*(5): 297 - 304.

Laddha, P.C. and Gupta, C.P.(1977). 'Effect of seed size on structural composition and quality of Bragg and Ankur varieties of soybean'. *Annual report of research 1975 - 76:* 184

Lamara, A,C., and Pava, H.M. (1983). 'Yield and agronomic trials of cv. Clark - 63 , a soybean variety, as affected by plant population density and phosphorus fertilization'.*Journal of Agricliture, Food and Nutrition , 5* (3): 617 - 631.

Lauer, M.J. and Blevins, D.G. (1989a). 'Dry matter accumulation and phosphorus Distribution in Soybean Growth on varying levels of phosphorus nutrition'. *Journals of Plant Nutrition , 12* (9): 1045 - 1060.

Lauer, M.J. and Blevins, D.G. (1989b). 'Flowering and podding characteristics on main stem of soybean grown on varying levels of phosphorus nutrition'. *Journal of Plant Nutrition , 12* (9) ; 1061 - 1072.

Lee, S.C., Choi, K.G., Kim., J.H. and Cheng, Y.N. (1989). 'Variation of Major characteristics in soybean varieties'. *Korean Journal of Crop Science, 34* (4); 440 - 448

Lins, I.D.G. and Cox,F.R. (1989). 'Effect of extractant and selected soil properties on predicting the correct phosphorus fertilization of soybean,. *Soil Science of American Journal , 53* (3): 813 - 816.

Mahajan, J.B., Biseon, D.C. and Sinha, S.B. (1982). 'Studies on uptake and utilisation of soil and fertilizer phosphorus by soybean as influenced by P - level and soil fertility status in Vortisol'. *Journal of Nuclear Agriculture and Biology* ,*11* (4) ; 113 - 115.

Majanbu, I.S., Ogunlela, V.B., Ahmed, M.K. and Olarewaju, J.D. (1985).
'Response of two Okra (*Abelmoschus esculentus* L., Moench). varieties to fertilizer on yield and yield components as influenced by Nitrogen and phosphorus application'. *Fertilizer Research*, *6* (3) Dept. of Agronomy and Plant Science, Ahmadu Bello University, Zaria, Nigeria. 257 - 267.

Major, D.J. (1977). 'Influence of seed size on yield and yield components of Rape'. *Agron. Journ., 69;* 541.

Marais, J.N. and Wiersma, D. (1975). 'P uptake by soybean as influenced by soil moisture stress in the fertilized zone'. *Agronomy Journal 67;* 777.

Markley, K.S. (1950). *Soybean and soybean products*. Inter science publishers, Inc., New York. 4 - 57pp.

Matar, A.E. (1977). 'Yield and Response of Cereals to Phosphoprus Fertilization under changing rainfall conditions'. *Agronomy Journal , 69;* 879.

Mckersie, B.D., Tones, D.T. and Yamamoto, S. (1981). 'Effect of seed size on germination, seedling vigour, electrolytic leakage and establishment of birdfoot trefoil (*Lotus corniculatus , L.)*'. *Canadian Journal of Plant Science 16* (2) : 337 - 343.

Mijindadi, N.B. (1987). 'The Relevance of Soybean to Nigerian Food Problems'. In *Proceedings of the 7th Annual National Soybean Conference (7)* , Nigeria. pp. 25.

Mohammed, M.A., Ali, A.H., Al-Fady, M.Y. and Kadir, A.A. (1988). 'Effect of seed size of some soybean and maize varieties on germination and other characters'. *Mesopotamia Journal of Agriculure, 20* (3) : 251 - 264.

Musa, U.T. (1990). 'Effect of seed size and phosphorus level on growth and yields of cowpea (*Vigna unguiclata,* L. , Walp). varieties'. Unpublished Agronomy Seminar, Dept.of Agron., A.B.U., Zaria, Nigeria, 10 - 11pp

Noman, A .G. (1963). *Soybean Genetics, Breeding, Physiology , Nutrition and Management.* Academic Press, New York, 149 - 151 pp.

Norman, A.G. (1978). *Soybean physiology, Agronomy and utilization.* Academic Press Inc., New York, 180 - 190.

Nyiakura, O. (1982). 'Soybean production in Nigeria,- Prospect and problems'. In *Proceedings of the 2nd National Meeting of the Nigerian Soybean Scientists (2)*, pp. 26.

Olufajo, O.O., Pal, U.R., Nnamdi, L.A., Adu, J.K. and Asenima, I.O.E. (1984). 'Influence of cultural practice on soybean yield in Nigerian savanna'. In *proceedings of the 4th National Meeting of the Nigerian soybean Scientists ,4. Pp.* 112 - 132.

Olufajo , O.O. (1987). 'Soybean response to N & P fertilization'. In *the Department of Agron. Annual Report 1987.* Pp. 19 - 20. Faculty of Agriculture, IAR/ABU, Zaria. Nigeria.

Orthoefer, F.T. (1978). 'Processing and Utilization of Soybean'. In Norman, A.G.(ed). *Soybean; Physiology, Agronomy and Utilization.* Pp. 219 - 246. Academic press,New York.

Oyekan, P.O. (1987). 'Effort to increase soybean production and utilization in Nigeria'. In *Proceedings of the 7th Annual soybean conference,* (7) .Pp. 13 - 20.

Paikera, A., Mishra, S.M. and Mishra, M. (1989). 'A note on effects of varying levels of Nitrogen and Phosphorus on yield attributes and yield of soybean'. *Orissa Journal of Agriculture, 2* (1) : 68 - 69.

Purseglove, J.W. (1974), *Tropical Crops;- Dicotyledons*. Longman group Ltd. London, 265 - 268pp

Queiroz, E.F.De, Gercia, A., Sfredo, G.J. and Cordeiro, D.S. Da. (1980). 'Response of soybean cultivarsto levels of phosphorus fertilizers'. Centro Nacional de pesquisa soja; 203 - 205. (*Soybean Abstracts, 4* (10), Abstr. 1658; 1981).

Reddy, P.N., Reddy, K.N., Rao, S.K. and Singh, S.P. (1989). 'Effect of seed size on qualitative trials in soybean (*G.max* L. , Merr.)'. *Seed Science and Technology , 17* (2) ; 289 - 295.

Robert, M.B.V. (1986). *Biology - A Functional Approach.* 4th ed. English language Book Society,. T. Nelson and sons Ltd., United Kingdom. 664pp.

Robinson, D.H. (1947). *Leguminous forage plants,* 2nd (ed). Edward Arnold & Co., London. 108 - 109pp.

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,IAR, Ahmadu Bello University, Zaria, Nigeria. 40 - 65pp.

Salnikov, A.I. (1977). 'Enzymes activity during germination of spring wheat seeds of different quality under conditions of low temperature and excessive soil temperature'. Uckenye Zpiski, Kazanskii Institute (180); 41- 46. (*Field Crop Abstracts*, *31* (6). Abstr. 3618; 1978).

Sanchez de la puente, L., Mangas , V.J. and Mortines Carrasco, P. (1976).
'Effects of N and P on leaf area of strawberrys. *Comptes Randus*, 2; 199 - 210. (*Soil and Fertilizers*. *41* (2) Abstr. 7 73, 1978).

Sergeer, V.K. (1978). 'Basal application of fertilizers to soybean cv, Aminskaya - 310 on meadow-chernozon soils of Amroprovincel Nauchuo- Tekhnicheskii byulleten; *Refereativuyi Zgurnal* 2.55. 242; 13-25. (*Field crop Abstracts*, *32* (1). Abst. 225; 1979).

Sestak, Z. , Catsky, J. and Jarius, P.G. (1971). *Plant photosynthetic production - Manuals of methods*, Dr. W. Junk, N.V. Publishers, Hague, Netherlands. 517 - 555pp.

Shibles, R..M ., Anderson, I..C. and Gibson, A.H. (1976). 'Soybean'. In Evans, L.T. (ed). *Crop Physiology*, 151 - 179 pp. Cambridge University Press, Cambridge.

Shukla, A., Sharman, Y.K. and Bargale, M. (1987). 'Chemical constituents of broad beans (*Vicia faba*, L) as compared to soybeans (*Glycine max*, L., Merrill) with special reference to their seed size.' *Indian Journ. of Nutrition and Dietetics*, *24* (11); 353 - 357.

Singh, A.R., Chaudhari, S.D. and Bhale, N.L. (1980). 'Effect of seed size on germination, testa weight and seedling vigour in *Sorghum bicolor*, L., Moench'. Research Bulletin of Marathwada Agricultural University 2 (11), India; 152 - 154.(*Crop physiology Abstract*, *7* (12). Abstr. 7489. 1981).

Singh, C.B., Mishra, R.K. and Mehta, S.K. (1978).' Note on the correlation between some seed characteristics and germination percentage in soybeans'. *Indian Journ. of Agricultural Science, 48* (2); 121 - 122.

Singh, R.M. And Jain T.C. (1966). 'Effect of phosphorus and Molybdate on T G O characters of Russian giant cowpea (*Vigna sirrensis).* In *Cowpea;- Abstacts of World Literature, 1*; 46 pp.

Singh, S.R., Rachie, K.O. and Dashaell, K.E. (1987). *Soybean for the tropics - resaerch, production and utilization,* IITA; John Wiley and Sons, Ltd, New York xvi,8 and 81pp.

Sisodia, G.S. (1987). 'Effect of seed size on yield in soybeans'. Seeds and forms *13* (4), India; 30 -31. (*Field Crop Abstracts, 4* (1). Abstr. 394; 1988).

Smith, T.G. and Campare Jr., H.M. (1975). ' Effect of seed size on soybean performance'. *Agron. Journ., 67*; 681 -685.

Snedecor, G.W. and Cochran, W.G. (1967). '*Statistical Methods*';6th ed. Iowa State University Press, Iowa, U . S . A . , p. 456.

Song, S.H., Lee, Y.I., Kwon, S.H., Song, I.M. and Kwon, K.H. (1990). 'Relationship between seed weight and agronomic traits in Korea native soybeans'. *Korean Journal of Crop Science,35*(1) ; 28 - 33 .

Souza, E.A., Andrioli . F., Bargantnar, J.G. and Percin, D. (1979). 'Effect of rates and Method of application of fertilizer to crops of soybean (*G. max*,L. Merr.) cultivar Santa Rosa'. Anais I. Seminario nacional de pesquisa de soja; 211 - 217.(Soybean Abstracts, 4 (1). Abstr. 323; 1981).

Souza, E.C.A. de., Trabuco, A.C., Coutinne, E.L.M. and Lima, A.D.L. (1984).
'Effect of broadcast of phosphate fertilizer on soybean (*G. max,* L., Merr.)'. Centifica 12 (1-2), Brazil; 85 - 89 (*Field Crop Abstracts ,39* (8). Abstr.5922; 1986).

Tanimu, B., Fisher, N.M.. and Yusuf, Y. (1982). 'Findings from recent Agronomic Research with soybeans at I A R . A.B.U., Zaria'. In *Proceedings of the 2nd National Soybean Scientists Conference,* No. 2 , Nigeria. 73pp.

Teixeira, M.C.C. and Costa, J.A. (1989). 'Effect of soybean seed size on vigour and the proportion of intergument, embryonic axis and cotyledons'. Levouro Arrozeira 42 (385), 12 - 15 (*Field Crop Abstracts, 43* (3), Abstr. 1906; 1991)

Uhlmann, F. (1990). 'The cereal, protein feed and potato market'. Agrarwirstschaff 38 (12) pp 377 -391. (*Soybean Abstracts, 13* (6), Abstr. 294; 1990).

Umekazi, T. and Matsomoto, S. (1989). ' Studies on internode elongation pattern in the main stem of four late soybean cultivars'. *Japanese Journal of Crop Science 58* (3); 364 -367.

Vieira, R.D., Munro, O.A., Fernandos, F.M. and Bazantto, D.A. (1986). 'Effect of phosphorus fertilization on yield and phenological characteristics of soybean (*G. max*, L., Merr.) in a cerrado soil'. Centifica 14 (1-2), Brazil; 19 - 27 etc. (*Field Crop Abstracts 42*(2), Abstr. 867; 1988).

Vines, A.E. and Rees, N. (1971). *Plant and Animal Biology II.* 4th ed.,Pitman Books Ltd, London. 346pp.

Vines, A.E. and Rees, N. (1972). *Plant and Animal Biology I* . 4th ed. Pitman Books Ltd, London. 488pp.

Whitehead, W.F., Mebrahtu, T. and Sapra, V.T. (1980). 'Effect of seed sizes on germination, growth and yield characteristics of three soybean cultivars'. *American sooiety of Agronomy* ; 5.

Williams. L.F. (1950). *Soybean and soybean products, I* , Inter - science publishers, Inc., New York, 115pp.

Wittwer, S.H. (1978). 'Production Potential of crops plants'. Gupta, U.S. (ed). In *crop physiology*, Pp. 353. Oxford and IBH publishing Co., New Delhi.

Woods, S.J. and Swearing, M.L. (1977). 'Influence of stimulated early lodging upon soybean seed yield and its components'. *Agron. Journ., 69* ; 239.

Xu, A.N., Wu, S.D. and Zeng, F.S. (1978). 'Genetics and Breeding studies of Growth characteristics in soybean seedlings; 1. 'Effect of seed size, temperature and moisture'. *Journ. of Agriculture and Forestry, 27*; 23 - 46.

Yev, T.J. (1990). 'Effect of phosphorus and Zinc on the growth, nodulation, and yield of soybean (*Glycine max.* L.; Merrill).' *Unpublished Agronomy Seminar*, IAR, ABU, Zaria, Nigeria , 22

Yoon, J.H. and Ryu, I.S. (1976). ' Study on the effect of base ration in plant and soil on soybean yield and growth'. *Research Report of the ofice of Rural Development. Soils Science Fertilizer, plant protection and microbiology 18.* Institute of Agricultural Science; Suweon, South Korea; 35 - 40.

Yuan, T.L., Lutrick, M.S. and Robertson, W.K. (1976). 'Response of soybeans and Oats to lime, phosphorus and potassium on paleudult',. In *Proceedings of soil and crop science Society of Florida , 38* ; 116 - 121.

Yusuf, Y. (1987). 'Effect of P- levels on yield and yield components of cowpea at Samaru'. Cowpea sub-programme, legumes and oil seeds Research Programme, Croping Scheme meeting, IAR, ABU, Zaria, Nigeria, 161 pp.

Zakaria, Z.Z., Schrader, V.N. and Boote, K.J. (1977). 'Soybean response to calcium and phosphorus under aluminium saturation'. *Soil and crop science society of Florida 36;* 178 - 181.

Zalawadia, N.M. and Patel, M.S. (1983). 'Growth response and phosphorus uptake by groundnut in calcareous soil in relation to applied phosphorus under varying soil conditions' *Journal of Indian Society of Soil Science, 31* (4): 486 - 490.

Appendix 1. Physical and chemical properties of the soil of the experimental site at Samaru collected up to a depth of 30cm in 1990.

Soil characteristics	Soil depth O - 30cm
Soil particle size (%)	
Sand	38.00
Clay	40.00
Silt	42.00
Texture class	Loam
Chemical characteristics	
p H (Water)	5.60
pH (0.01 M $CaCl_2$)	4.70
Organic carbon (%)	0.61
Available P(PPM)	7.02
Total N (%)	0.04
Exchangeable bases (Meq/100g)	
K	0.16
Ca	1.72
Mg	0.57
Na	0.12
C.E.C	3.35

Appendix 2. Total rainfall, mean temperature and relative humidity at ten days interval during the period of the experiment at Samaru, in 1990.

Month	Days	Total Rainfall (mm)	Mean Temperature (0^0 C)	Relative Humidity (%)
May	1 - 10	80.3	14.8	53.9
	11- 20	25.8	15.4	49.5
	21- 31	17.2	15.4	48.1
June	1 - 10	20.4	16.0	55.8
	11 - 20	62.1	16.6	60.4
	21 - 30	73.2	16.2	65.9
July	1 - 10	67.8	17.1	62.7
	11 - 20	[illegible].6	15.7	66.7
	21 - 31	69.5	16.2	67.1
August	1 - 10	109.2	16.5	67.6
	11 - 20	44.7	15.9	69.7
	21 - 31	101.1	17.5	63.0
Sept.	1 - 10	54.6	17.0	67.4
	11 - 20	58.8	17.1	63.1
	21 - 30	18.1	18.8	56.1
Oct .	1 - 10	Nil	17.3	53.1
	11 - 20	Nil	14.2	54.1
	21 - 31	Nil	11.6	34.5

Source : Soil Science Section, Institute of Agricultural Research, Samaru, A.B.U, Zaria, Nigeria.

BIOGRAPHY : Ndako Soolaymann Majin

Name:	N . S . Majin
Date/Place of Birth:	June 1958, Bida, Niger State.
Business Address:	Department of Basic and Applied Sciences, Niger State Polytechnic, P.M.B. 1, Zungeru.
Home Address:	Liman Nasara House, Nasara-fu Road, P.O.Box 225, Bida, Niger State.

Institut ions attended and Qualifications:

Institution:	Date	Qualification
Kofar Eyagi / Umar Sanda Primary School, Bida	1968 - 1973	Leaving Sch. Cert.
Government Secondary School, Rijau	1973 - 1978	W . A. S. C.
School of Basic Studies, A.B.U. Zaria.	1978 - 1979	IJMB (A' Level)
Ahmadu Bello University,	1979 - 1982	B.Sc. (Botany)

Post(s) Held since Award of First Degree

Organization	From		To	Position
Mbieri Technical School, Owerri	1982	-	1983	Teacher (NYSC)
Government Secondary School, Suleja	1983	-	1984	Teacher
ZUCAS/Niger State Polytechnic, Zungeru.	1984	-	Present	Senior Lecturer / HOD(Sc).

Year of Admission for Post Graduate Studies:	November 1989
Admission Number:	M.Sc./ACR/ 0631 / 89 - 90 .