THE EFFECTS OF SEED SIZE AND NUMBER OF SEEDS PER HOLE ON THE GROWTH AND YIELD OF COWPEA (*Vigna unguiculata* (L) Walp) VARIETIES

BY

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BY

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DEPARTMENT OF AGRONOMY
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AHMADU BELLO UNIVERSITY
ZARIA (NIGERIA)

NOVEMBER 1988

DECLARATION

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

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CERTIFICATION

This thesis titled "THE EFFECTS OF SEED SIZE AND NUMBER OF SEEDS PER HOLE ON THE GROWTH AND YIELD OF COWPEA (*Vigna unguiculata* (L) Walp.) VARIETIES" by Bala Abubakar Sahabi meets the regulations governing the degree of Master of Science of Ahmadu Bello University Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to my late dear brother

AHMADU ABUBAKAR HAKIMI

whose help and encouragement are unforgetable.

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ABSTRACT

An experiment was conducted at Samaru during the 1987 wet season to study the effect of seed size and number of seeds per hole on the growth and yield of cowpea (Vigna unguiculata (L) Walp) varieties. The treatments consisted of two cowpea varieties (Kanannado (local) and SVU 48), three seed sizes (large, medium and small) and four- number of seeds per hole (one, two, three and four seeds per hole).

The study revealed that, large sized seeds was more vigorous in vegetative growth and had higher yield and yield components than small sized seeds. One seed planted per hole had higher number of leaves, branches, leaf area, shoot dry weight and number of pods, seeds, weight of seeds per plant and 100 seed weight than three and four seeds planted per hole, but was not significantly different from two seeds planted per hole. However, two seeds planted per hole produced higher grain yield than one and four needs planted per hole. Local Kannannado variety was more vigorous in vegetative growth than SVU 48. However, there was no significant difference in grain yield between the two varieties. Interactive effect of seed size and cowpea variety significantly influenced vegetative growth characters. SVU 48 had statistically the same number of branches irrespective of the seed size planted, whereas the number of branches oduced by local Kanannado variety was significantly different. Grain yield was significantly and positively correlated with yield components (number of flowers, pods

seeds and seed weight per plant) and vegetative growth characters (stem length and leaf area per plant),

Based on these findings it can be concluded that yield benefits can be obtained from the use of large sized seeds. There is also the possibility of getting high yields from planting two sound seeds per hole that one, three and four seeds per hole and later thin to two plants per stand. It may tnerefore, not be necessary to spend extra time and resources to thin, if two cowpea seeds are sown per hole.

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Chapter 1

INTRODUCTION

1.1 Importance, Production trends and Constraints

Cowpea (Vigna unguiculata (L.) Walp) is one of the most important cultivated grain legumes. It is one of the major sources of protein among the grain legumes grown in the tropics and sub-tropics.

Cowpea originated from tropical Africa, from where it spread to Egypt, Asia and Mediterranean (Mehra, 1963; Sauer, 1952; and Singh et al., 1971). It was taken to West Indies in the 16th century by the Spaniards and got to United States of America in the 18th century (Wight, 1907). Thus, it is widely distributed and cultivated all over the tropical and sub-tropical regions of the world.

When compared with cereal crops, cowpea plays a more important role in animal and human nutrition because of its high protein content. The dry edible seed for which it is cultivated contains about 23-25% crude protein. Cowpea is a relatively cheap, acceptable, digestable and nutritionally adequate substitute for animal protein and it compliment staple food such as cereals, root and tuber crops. Edible grain legumes are the only source of increasing the production of plant protein (Doughty and Orraca-Tetteh, 1966) and in particular cowpea is the most suitable, since it is the most adapted in the tropical and sub-tropical regions of the world (Summerfield et al., 1974).

The biggest attribute of cowpea is that, it provides a wide range of edible products over the growing season (Nachie and Robert, 1974, and Summerfield et al., 1974). Its tender green shoot and leaves, unripe whole pods, green seeds and dry seeds are all untilised as sources of palatable high quality protein. The value of the crop as a pot-herb in the tropical Africa is enhanced by the fact that, the plant continues to produce new leaves if cutback at an early stage (Leakey and Wills, 1977). These characteristics render the crop useful as green manure, cover crop and fodder for hay, silage and pastures. In the United States, the green seeds are sometimes roasted like peanut. Scorched seeds are occasionally used as coffee substitute (Purseglove, 1974). Fibre is also obtained from the peduncles of certain cultivars in northern Nigeria (Summerfield et al., 1974). The roots are of medicinal value and are also eaten in parts of Sudan and Ethiopia (Purseglove, 1974). In India, the leaves are used in dyeing to obtain a green dye (Westphal, 1974). The consumption of cowpea in the tropical region (e.g. Nigeria) is greater than that of most grain legumes, partly because it is easy to cook using unsophisticated methods and also it is preferred by most of the indegenous population (Stewart, 1976).

Although, Nigeria is the leading producer of cowpea in the world, grain yields per hectare are generally low compared with those of other countries. Average yields of 189 kg/ha (Anon, 1975) and 250 kg/ha (Hartman, 1983) have been reported in Nigeria, compared with 3,105 kg/ha in Egypt and 651 kg/ha in Malawi (Anon, 1975). Despite the high yielding ability of cowpea, low productivity is experienced in most producing countries due to combination of factors such as vagaries of weather, lack of suitable and adaptable varieties, high susceptibility to weed competition and diseases and pests attack (Stalon et al., 1963, and Hartman, 1983), low plant population and poor pest management practices (Summerfield, 1974). Research work has shown that with optimum plant population, accompanied by adequate management practices, yield can be improved tremendously.

Several workers have shown the importance of seed size as a factor for selecting planting materials and its significance on the growth and yield of many crops. The size of planting material is a controllable factor which could introduce differences in the performance of a crop. According to Blackman (1919) the dry matter attained at any period by an annual plant depends on its initial seed weight. Poehlman (1959) also stated that, despite

similarities in genetic constitution, large and small seeds of a crop variety would produce seedlings which differ in size due to differences in the amount of stored food material in the seeds. After successful establishment, however, the growth and final yield of plants from small seeds may be as great as those of plants from larger seeds (Hughes et al., 1957). Farmers plant four or more seeds per hole irrespective of seed size without subsequent thinning. It will be interesting to find out whether the farmer will be better off by planting less number of seeds of larger sizes to get maximum seedling establishment, performance and yield or not. The need to generate data and provide information on the effect of seed size and number of seeds planted per hole on the growth and yield of cowpea to our local farmers justifies this study.

The objective of this study, therefore, is to investigate the effect of seed size and number of seeds planted per hole on the growth and yield of cowpea and their interactions under field conditions.

Chapter 2

LITERATURE REVIEW

2.1 Effect of Seed Size on Growth and Development

Rapid and uniform stand establishment with vigorous seedlings is basic to acceptable plant performance. Seed size has been shown to be important factor in this respect, for a number of agronomic crops (Clark and Peck, 1968; and Wester and Magruder, 1938). The results of earlier studies on bushlima beans (Wester, 1964), snapbeans (Clark and Peck, 1968) and grass and legumes (Murphy and Arny, 1939) showed the superiority of heavier or larger seeds particularly when equal number of seeds per unit area were planted. In these studies, almost all seeds from large seed sizes gave higher germination percentages, early stand establishment and high yield than small seed sizes. However, if planted on equal weight basis small seeds outyielded large seeds due to increased number of plants per unit area (Clark and Peck, 1968). The size of seeds permits more precise planting, uniformity of emergence of seedlings and crop development (Wester, 1964).

Like in most crops, seed size may play a vital role in germination, growth and performance of cowpea. Successful crop production depends on a number of environmental and cultural parameters. Of all the

variables affecting stand establishment and plant performance, Seed size is one of the traits that can be easily manipulated and be of economic important (Clark and Peck, 1968).

The effect of seed size on germination, growth and yield has been widely investigated. It is generally held that, large seeds lead to high germination, vigorous growth and ultimately high yield (Harper and Obied, 1967). The test for vigour and the criteria used for its measurement have, however, varied with crops. Seed size had been reported to influenced germination, seedling emergence, growth and yield of peanuts and bushlima beans (Gorbet, 1977; Wester, 1964; and Wester and Magruder, 1938). Increase in seed size has been positively correlated with germination percentages, seedling vigour and yield in the field (Beveridge and Wilsie, 1959; Black, 1956, and Fehr and Probst, 1971). Although not all of the responses are the same among crops, reliable evidence supports the use of larger seeds within a given genotype.

Large seeds germinate faster than small seeds, therefore, become well established (Boyd et al., 1971). Franson and Cooper (1976) showed that seedling from large sainfoin seeds emerged and developed first and second leaves faster than seedlings from small seeds. Similarly, Gorbet (1977) reported that, the rate of emergence, seedling vigour and young plant size of peanut consistently favoured the

larger seed sizes. However, Lawrence (1959) working with intermediate wheat grass (Agropyron intermedium) was unable to show an emergence response due to seed size in either rate or total emergence. Green et al. (1965) reported that the small seeds produced by late planted soybeans emerged faster and had higher germination percentages than large seeds of the same variety. Studies with soybeans, snapbeans, limabeans and runner peanuts have proved the superiority of larger or heavier seeds over small seeds, particularly when equal number of seeds per unit area are planted (Clark and Peck, 1968, Wester and Magruder, 1938 and Gorbet, 1977).

Sivasubramanian and Ramakrishnan (1974) evaluated the effect of seed sizes on the germination and field emergence potential using a number of simple vigour tests. All the tests confirmed the superiority of large sized seeds over small and shrivelled seeds. The differences in kernel size were attributed to differences in the size of cotyledons and the total protein and amino-acids content stored in them.

The effect of seed size on seedling size is very apparent. According to Blackman (1919) the dry matter attained at any period by an annual plant depends on its initial seed weight. Poehlman (1959) also stated that, despite similarities in genetic contribution, large and small seeds of a crop variety would produce seedlings,

growth (Carleton and Cooper, 1972). Other techniques such as speed of germination (MacGuire, 1962), speed of elongation (Carleton et al., 1968); emergence force (Shibles and MacDonald, 1962) and relative growth rate (Chuangsheng, 1963) also have been used as a measure of seedling vigour.

The size of a legume seedling may be the result of either genetic or environmental factors or a combination of both. Kidd and West (1919) remarked that, environment during seed ripening could affect the vigour of the seedling. They concluded that, environmental conditions may:-

i) directly affect the seeds because of its position on the plant; or

ii) indirectly affect the seeds because of an influence on the plant itself.

Gorbet (1977) in a study of florunner peanut showed that, large seeds were associated with higher seed protein, superior emergence, greater leaf area and vigour of x seedlings, larger plants and greater yield than small seed sizes. This could be because of high leaf area index which indicated high photosynthetic productivity of the plant from large seeds (Black, 1957) similarly Dharmalingan and Ramakrishnan (1978) showed that plants

raised from small grades of both colour categories of blackgram (Vigna mungo) had less number of leaves than large grade. The leaf area of the first pair of leaves of plant from the seed of top two grades, irrespective of colour categories showed two to three fold increase. Distinctly lower leaf area values registered in plants raised from small seeds had revealed linear relationship with seed sizes (Dharmalingam and Ramakrishnan, 1978) which was in conformity with the findings of Black (1958) in subterranean clover and Harper and Obied (1967) in flax.

Importance of seed size seems to be the most greatest during the early stages of plant growth (Oexeman, 1942). The superiority of larger seeds in producing more vigorous and better plant is more pronounced in the case of deeper planting or unfavourable conditions in the early stage of growth, when the seedlings have greater dependence on the food reserves of the seed. But under favourable conditions and/or with advance in the growth stage, the differences are generally less marked, diminishing and in certain cases completely levelled off (Harper and Obied, 1967; Murphy and Arny, 1939 and Oexeman, 1942). The results of numerous studies on legume herbage, alfalfa, sweet clover and soybeans indicated that large seed produced plants of more vigorous growth in the initial

stages than that of small seeds (Black, 1959; Dhillon, 1973 and Erickson, 1946). But the early superiority in favour of the seedling from large sized seeds decreased and in certain cases was eventually lost with advance in growth stage. However, in the case of blackgram, a comparatively short duration crop, the plant from large seeds, not only maintained their greater height throughout the growing season, but also widened the differences due to their superiority compared to those from small seeds with the advance in age (Dhillon and Kler, 1976).

2.2 Effect of Seed Size on Yield and Yield Components

Smith and Camper (1970) in a study on the effect of seed size on soybeans performance found that, plants grown from large seeds were taller and had higher seed yield than plants from small seeds. However, Fontes and Ochlrogge (1972) reported an increase in soybeans yield with large seeds in one test, but no yield difference in the second test. While Edje and Wahab (1973) obtained lower yield of soybeans from small seed sizes. However, Singh et al. (1972) and Sato and Kamiyama (1956) working on soybeans reported no difference in yield due to seed sizes.

Kidd and West (1919) reported that plants from plump seeds produced a larger number of flowers, which produced more numerous and larger fruit. Earlier maturity in the case of peas, was achieved by selecting large seeds. Also the growth and yield of the resulting plants were proportional to their initial "food capital" following "compound interest" law (Dhillon and Kler, 1976). In the study of soybeans, Fontes and Ochlrogge (1972) reported that, plants from large seeds had greater grain yield, more pods and number of branches per plant and a smaller number of barren plants than small seeded plants. They maintained that large seeded soybeans plants produced large weight of grains than small seeded plants but number of seeds per pod was not affected. However, average number of barren plant per plot was small for large seed sizes, because small seeds were most frequently shaded to their maximum rate of elongation and hence were more frequently suppressed (Fontes and Ochlrogge, 1972) than large seeds. The results of numerous studies on soybean had shown that heavier or larger seeds exhibited superior emergence, embryo size and fresh weight of roots, shoots and total plant weight. They excelled in vigour, height, stem diameter, number of branches and pods per plant, dry weight, grain yield and produced

less barren plants (Tandon and Gulatin, 1968; Burris et al., 1971; Fontes and Ochlrogge, 1972; Tawee, 1972; Burris et al., 1973 and Smith and Camper, 1975). Although, larger seeds produced larger embryos, relative dry matter accumulation did not vary appreciably (Burris et al., 1971), subsequently, the same authors in 1973 reported that plants from small seeds exhibited higher photosynthetic rates, however, the largest seed size showed greater overall emergence percentage, leaf area in the field and yielded significantly more than small sized seeds when grown at uniform population. On the other hand, small and medium sized seeds were reported to give higher yields (Dhillon, 1973 and Edward and Hartwig, 1971) than large sized seeds, while some showed no significant difference once the stand was established (Edje and Burris, 1971 and Singh et al., 1972).

2.3 Effect of Number of Seeds per Hole on the Growth and Yield of Cowpea

There is little or no information on the effect of number of seeds per hole on the growth and yield of crops in general and cowpea in particular. In a study on the effect of number of plants per stand on the growth and yield of cowpea, it was found that two plants per stand was the optimum number of plants for high yield in cowpea (Anon, 1979) when one, two and three plants were left per stand at a

spacing of 76 cm by 30 cm. The low yield attributed to three plants per stand was due to increased inter-plant competition (Anon, 1979). Generally, the number of seeds planted per hole determined the number of seedlings that would emerge per hill if not thinned to the required plant per stand. Since large seeds usually give higher germination percentages, better seedling emergence, greater seedling vigour and stand establishment than small seeds (Wester and Magruder, 1938; Wester, 1964 and Gorbet, 1977), less number of large seeds may be needed than small seeds.

Chapter 3

MATERIALS AND METHODS

3.1 Location

The experiment was conducted at the Institute for Agricultural Research farm at Samaru Zaria, Nigeria ($11^{o}11'N$ $07^{o}38'E$, 686m above mean sea level) during the 1987 wet season.

Samaru lies in the Northern Guinea Savanna zone of Nigeria. It has an average annual rainfall of about 1060mm, mostly distributed between months of May and October, with a mean monthly minimum and maximum temperature of 20 ^{o}C and $30^{o}C$ respectively during this period. The soil is moderately deep, well drained and characteristically tropical sandy loam. Results of analysis of the physical and chemical properties of soil from the site used for this experiment are presented in appendix 1. The climatological data collected during the 1987 growing season are presented in appendix 2. The field was cropped with maize the previous year.

3.2 Treatment and Experimental Design

The treatments consisted of two cowpea varieties (Kanannado (local) and SVU 48), three seed sizes (large, medium and small) and four number of seeds per hole (one, two three and four seeds per hole). The treatments are

factorially combined and layed out in a randomized complete block design with four replications. The gross and net plot sizes were 20.25 m^2 and 13.5 m^2 respectively. The gross plot consisted of six ridges of 75 cm width and 450 cm long, while the net plot consisted of the four inner ridges of the gross plot.

3.3 Grading into Seed Sizes

Seeds from two cowpea varieties (local Kanannado and SVU 48) were selected and graded into three sizes. This was done by observing the seeds visually and then separating them into three seed sizes, large, medium and small. These were later graded using round perforated metal sieves having different hole diameters at the Department of Civil Engineering, Ahmadu Bello University, Samaru Zaria. The sizes used for kanannado were: Large = those that remained on the screen with a mesh size of 7.4 mm; medium = those that passed through the screen with a mesh size of 7.4mm but remained on the one with a mesh size of 6.6 mm; and small 6.6mm screen. The seed sizes used for SVU 48 were: Large = those that remained on the screen with a mesh size of 6.6mm; medium = those that passed through the screen with a mesh of 6.6mm but remained on the one with a mesh size of 6.2mm; and small = those which passed through 6.2mm screen.

One thousand seeds (1000) from each size of each variety were then weighed as shown below.

Variety	Seed sizes (1000 seeds)		
	Large	Medium	Small
Kanannado	280	207	136
SVU 48	204	161	121

3.4 Field Operations

3.4.1 Soil sampling and analysis

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

The particle size analysis of the soil was done by hydrometer method, organic carbon content by Walkley and Black method, soil pH in water and 0.01M $CaCl_2$ using a pH

meter. Available P by Kjeldahl method, exchangeable bases by ammonium acetate saturation and cation exchange capacity by acetate extraction and distillation (Black, 1965).

3.4.2 Land preparation

The land was ploughed, harrowed to a fine tilth and ridged at 75 cm width. The field was marked out into 96 plots of 20.25 m^2 (4.5 m x 4.5 m) size each. Paths of 1m across the rows and 75 cm (one ridge) along the rows were allowed to separate adjacent plots.

3.4.3 Fertilizer application

Single superphosphate (SSP) was broadcast at the rate of 37.0 kg P_2O_5/ha.

3.4.4 Planting and planting materials

The crop was planted on the 15th of July, 1987. Two varieties of cowpea, Kanannado (local) and SVU 48 were used. Kanannado is a spreading late maturing, day-length sensitive type with large white seeds; whilst SVU 48 is a semi-upright, early maturing, day-length insensitive variety with medium to large brown seeds (Anon. 1985).

One, two, three or four seeds were planted from each seed size category per hole at 4-5 cm depth, on 75cm ridges. The crop was thinned four weeks after germination to maintain two plants per stand in the plots where more than two seeds were planted.

3.4.5 Weed and pest control

Galex 500 E.C. (metolachlor + metobromuron) a pre-emergence herbicide was used at 5 l/ha to suppress weed growth. This was applied a day after sowing. One supplementary hoe-weeding was done when the crop was 6 weeks old to check weed growth.

To control insect pests a mixture of Cymbush (cypermethrin) 10 E.C. and Rogor (dimethoate) 40 E.C. was used at the rate of 500 ml + 500 ml in 100 litres of water per hectare and sprayed using CP-3 knapsack sprayer. Spraying started 4 weeks after planting when insects infestation was noted and continued forthnightly upto flowering period. During flowering and podding the crop was sprayed at weekly intervals, using the same rates.

In controlling fungus infections, Benlate + Dithane M45 were used at the rate of 0.6 kg + 2.5 kg/400 litres of water per hectare, starting from four weeks after planting and continued at two weeks intervals until crop maturity.

3.4.6 Harvesting

SVU 48 was harvested at 12 weeks after planting, while Kanannado was harvested two weeks later. Harvesting was done by hand picking and pods and putting them in separate bags for each net plot for further analysis.

3.5 Observation and Data Collection

3.5.1 Assessment of pre-harvest parameters

Stand count was taken a week after planting. Assessment of parameters such as number of leaves, number of branches per plant, stem length, leaf area per plant and shoot dry weight per plant, began at 4 weeks after planting and continued at two weeks interval till the 10th weeks after planting.

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

Number of days to first flowering, days to 50% flowering, number of flowers per plant and stand count at harvest were also recorded.

3.5.2 Assessment of post-harvest parameters

Parameters assessed after harvest included: number of pods per plant, number of seeds per plant, weight of seeds per plant, weight of 100 seeds and the threshing percentage. The crude protein content of the grains was also determined.

3.5.3 Analysis of Data

Data collected were subjected to analysis of variance to test for the significant effects of the treatments using the 'F' test as described by Snedecor and Cochran (1967). The multiple comparison procedure of the least significant difference (LSD) was used to compare means of varieties, seed size and number of seeds per hole and their interactions. The Duncan Multiple range test (DMRT) (Duncan, 1955) was also used to compare the treatment means. Analysis of correlation co-efficients between growth characters, yield components and grain yields of cowpea was also done to determine their relationships.

Chapter 4

RESULTS

4.1 Effect of Seed Size and Number of Seeds per Hole on the Growth of Cowpea

4.1.1 Germination count

The results obtained indicated that, germination count was not in any way affected by number of seeds planted per hole and cowpea variety (Table 1). However, seed size significantly affected germination count. The large sized seeds gave significantly higher germination count (78.6%) than small sized seeds (71.6%) but was not significantly different from the medium sized seeds (75.9%). The difference between small and medium seed sizes was not significant.

The interactive effects of seed size and number of seeds planted per hole and cowpea variety on the germination count were not significant.

4.1.2 Stem length

Stem length was significantly influenced by both seed size and cowpea variety, while the number of seeds planted per hole had no significant effect (Table 2).

The length of plants increased significantly with increase in seed size. Large seeds gave the tallest plants, followed by the medium seed size, while the small sized seeds

Table 1 Effect of seed size and number of seeds per hole on germination percentage and stand count at harvest of cowpea at Samaru in 1987.

Treatment	% Germination	Stand count at harvest
Seed Size		
Small	71.594b	84.406b
Medium	75.064ab	94.094a
Large	78.637a	99.250a
SE (±)	1.703	2.469
Number of seeds/hole		
1	72.725a	52.667b
2	73.882a	106.125a
3	74.315a	108.125a
4	79.472a	107.417a
SE (±)	1.967	2.851
Varieties		
Kanannado	74.171a	90.063b
SVU 48	76.025a	97.104a
SE (±)	1.391	2.016

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

Table 2 Stem length of cowpea plants (cm) as influenced by seed size and number of seeds per hole at Samaru in 1987.

Treatment	Weeks after planting (WA) 4	6	8	10
Seed Size				
Small	11.882c	21.803b	49.397c	76.998c
Medium	13.948b	25.912b	60.838b	107.988b
Large	17.148a	34.784a	89.658a	127.157a
SE (±)	0.230	1.471	3.402	3.962
No. of seeds/hole				
1	14.205a	27.050a	68.557a	105.824a
2	14.315a	27.758a	61.153a	108.813a
3	14.053a	26.149a	70.176a	98.732a
4	14.731a	29.043a	66.638a	108.488a
SE (±)	0.865	1.699	3.928	4.575
Variety				
Kanannado	15.997a	34.550a	79.571a	129.831a
SVU 48	12.655b	20.450b	53.69ab	79.598b
SE (±)	0.188	1.201	2.778	3.235

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

gave the shortest plants throughout the sampling period.

The local Kanannado variety was significantly taller throughout the growing season than variety SVU 48.

The interaction between seed size and cowpea variety on plant stem length was significant throughout the sampling period (Table 3). Small and medium sized seeds, irrespective of crop variety produced similar stem length from 4 to 8 weeks after planting, thereafter, the difference was significant, whereas with large seeds, the differences in stem length were significant throughout the sampling period.

4.1.3 Number of leaves per plant

The number of leaves per plant was significantly influenced by seed size, number of seeds planted per hole and cowpea variety (Table 4). The number of leaves per plant was significantly influenced by the seed size upto 8 weeks after planting, thereafter, seed size had no significant effect. Large sized seeds produced more number of leaves per plant than small sized seeds. However, there was no significant difference between medium size seeds after 4 weeks after planting.

Table 3 The interactive effects of seed size and cowpea variety on plant height (cm) at Samaru in 1987

Seed Size	- Weeks after planting (WAP - 4 Cowpea Varieties		6 Cowpea Varieties		8 Cowpea Varieties		10 Cowpea Varieties	
	Kanannado	SVU 48	Kanannado	SVU 48	Kanannado	SVU 48	Kanannado	SVU 48
Small	12.886b	10.879b	26.085	17.522d	63.457bc	35.337d	92.254c	60.741d
Medium	15.637b	12.259b	32.673b	19.151d	69.173b	52.503c	135.357b	80.619c
Large	19.467a	14.828b	44.892a	24.676	106.084a	73.233b	160.882a	97.453c
SE (±)	0.325		2.080		4.811		5.603	

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

Table 4: Number of leaves per plant of cowpea as influenced by seed size, number of seeds per hole and variety at Samaru in 1987.

Treatments	Weeks after planting			
	4	6	8	10
Seed-Size				
Small	12.265c	25.130b	44.616c	111.803a
Medium	15.483b	29.192b	52.129b	89.48a
Large	20.303a	34.612a	69.314a	124.055a
SE (±)	0.569	1.499	2.733	23.799
Number of seeds/hole				
1	17.551a	33.359a	61.385a	165.856a
2	15.549b	29.583ab	57.194ab	106.013ab
3	15.450b	29.039ab	54.569ab	89.162ab
4	15.520b	26.588b	48.256b	72.766b
SE (±)	0.657	1.731	3.155	27.480
Variety				
Kanannado	20.515a	37.147a	69.674a	159.019a
SVU 48	11.519b	22.142b	41.028b	59.879b
SE (±)	0.465	1.224	2.231	19.431

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

One seed planted per hole had significantly higher number of leaves per plant than two, three and four seeds planted per hole. The difference in the number of leaves produced per plant was not significant when two, three and four seeds were planted. Local Kanannado variety had significantly higher number of leaves per plant than SVU 48.

The interactive effect of seed size and cowpea variety on the number of leaves per plant at 4 weeks after planting was significant (Table 5). The SVU 48 produced statistically the same number of leaves per plant when small and medium sized seeds were planted whilst local Kanannado variety produced significantly different number of leaves per plant when small or medium sized seeds were planted.

4.1.4 Total leave area (cm^2) per plant

The total leaf area per plant was significantly influenced by seed size, number of seeds planted per hole and cowpea variety (Table 6).

Large sized seeds gave significantly higher total leaf area per plant than medium and small sized seeds throughout the sampling period. However, differences in total leaf area between medium and small sized seeds were significant at 4 and 10 weeks after planting only.

Table 5: Interactive effect of seed size and cowpea variety on number of leaves/plant at 4 weeks after planting at Samaru in 1987.

Seed Size	4 weeks after planting	
	Cowpea varieties	
	Kanannado	SVU 48
Small	14.947c	9.583e
Medium	19.823b	11.144de
Large	26.776a	13.831cd
SE (±)	0.805	

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

Table 6 Total leaf area (cm^2) per plant of cowpea as influenced by seed size and number of seeds per hole at Samaru in 1987.

Treatment	Weeks after planting 4	6	8	10
Seed Size				
Small	463.346c	926.227b	1795.640b	2231.450c
Medium	679.149b	950.182b	2189.190b	3169.610b
Large	976.451a	1388.380a	2909.120a	4365.330a
SE (±)	43.553	71.523	147.044	175.383
No. of seeds/hole				
1	763.206a	1374.020a	2714.250a	4205.500a
2	751.064a	1107.050b	2442.060a	3315.320b
3	668.170a	940.390b	2201.620bc	2983.760bc
4	642.822a	935.590b	1834.010c	2517.270c
SE (±)	50.292	82.588	169.792	202.515
Varieties				
Kananado	929.820a	1329.050a	2418.050a	5000.860a
SVU 48	482.811b	649.476b	2177.910b	1510.070b
SE (±)	35.562	58.398	120.061	143.200

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

Total leave area per plant was not influenced by the number of seeds planted per hole at 4 weeks after planting. However, one seed planted per hole gave significantly higher total leaf area per plant throughout the rest of the sampling period. There was no significant difference in total leaf area produced when two or three seeds were planted but the difference was significantly higher compared to when four seeds were planted per hole.

The local Kanannado variety had significantly higher total leaf area per plant throughout the sampling period.

The interaction between seed size and cowpea variety on the total leaf area per plant at 6 and 10 weeks after planting was statistically significant (Table 7). Irrespective of the medium and large sized seeds planted, variety SVU 48 produced statistically the same leaf area per plant whereas with local Kanannado variety the leaf area per plant were significantly different.

4.1.5 Number of branches per plant

Number of branches per plant was significantly influenced by seed size, number of seeds planted per hole as well as cowpea variety (Table 8). Number of branches produced per plant increased significantly as seed size increased. The large sized seeds had significantly higher number of branches than small sized seeds.

Table 7 Interactive effect of seed size and cowpea variety on leave area/plant at 6 and 10 weeks after planting at Samaru in 1987.

	6 weeks after planting		10 weeks after planting	
	Cowpea Varieties		Cowpea varieties	
Seed Size	Kanannado	SVU 48	Kanannado	SVU 48
Small	1048.190bc	810.26ad	3347.160c	1115.750e
Medium	1164.270b	736.098cd	4842.300b	1496.910de
Large	1774.690a	1002.070bcd	6813.120a	1917.550d
SE (±)	101.149		248.028	

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

Table 8 Number of branches per plant of cowpea as influenced by seed size, number of seeds per hole and variety at Samaru in 1987.

Treatments	Weeks after planting			
	4	6	8	10
Seed-size				
Small	1.781c	2.969c	3.906c	5.21c
Medium	2.781b	3.594b	4.963b	6.719b
Large	3.906a	4.375a	5.656a	8.906a
SE (±)	0.168	0.179	0.182	0.486
Number of seeds/hole				
1	3.25a	4.125a	4.292a	8.625a
2	2.75a	3.750ab	4.667b	7.000b
3.	2.625a	3.250b	4.208b	6.208b
4	2.665a	3.450b	4.667b	5.958b
SE (±)	0.194	0.206	0.210	0.561
Variety				
Kanannado	3.667a	4.521a	5.750a	9.229a
SVU 48	1.979b	2.77ab	3.667b	4.667b
SE (±)	0.137	0.146	0.149	0.397

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

Number of branches per plant was not in any way affected by the number of seeds planted per hole at 4 weeks after planting. However, one seed planted per hole gave significantly higher number of branches than two, three or four seeds per hole at subsequent samplings except at 6 weeks after planting when there was no difference between one and two seeds per hole. The differences between the number of branches produced per plant when two, three and four seeds were planted per hole were not significant except at 10 weeks after planting when two and three seeds per hole had higher number of branches than four seeds per hole.

Kanannado had significantly higher number of branches per plant than SVU 48 throughout sampling periods.

The interaction between the number of seeds planted per hole and cowpea variety on the number of branches per plant were significant at 10 weeks after planting (Table 9). With all the number of seeds planted per hole variety SVU 48 produced statistically the same number of branches per plant, whilst with local Kanannado variety the number of branches produced per plant were significantly different.

Table 9 Interactive effect of number of seeds/hole and cowpea varieties on number of branches/ plant at 10 weeks after planting at Samaru in 1987.

No. of seeds/hole	10 weeks after planting	
	Cowpea Varieties	
	Kananmado	SVU 48
1	12.250a	5.600de
2	9.667b	4.333e
3	7.667b	4.750e
4	7.333cd	4.583e
SE (±)	0.794	

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

4.1.6 Shoot dry weight per plant

Shoot dry weight per plant was significantly influenced by seed size, number of seeds planted per hole and cowpea variety (Table 10) shoot dry weight per plant increased significantly with increasing size of seeds planted; large sized seeds producing significantly heavier plants than small sized seeds.

Planting one seed per hole produced significantly higher shoot dry weight per plant than two, three or four seeds per hole on all sampling dates except 4 weeks after planting. Shoot weights of three and four seeds per hole were similar throughout the sampling period, while planting two seeds per hole resulted in a higher shoot weight than planting either three or four seeds per hole only at 10 weeks after planting.

The local Kanannado variety produced significantly higher shoot dry weight per plant than SVU 48 throughout the sampling period.

The interactive effects of seed size and cowpea variety on shoot dry weight per plant was significant at 4 weeks and 6 weeks after planting (Table 11). With either small and medium or medium and large seeds, SVU 48 had similar shoot dry weight at 6 weeks after planting, whereas with local Kanannado variety shoot dry weight was statistically different.

Table 10: Shoot dry weight (g) per plant of cowpea as influenced by seed size, number of seeds per hole and variety at Samaru in 1987.

Treatments	Weeks after planting 4	6	8	10
Seed Size				
Small	1.865c	8.840c	28.392b	51.808c
Medium	2.489b	11.969b	31.375b	67.270b
Large	3.956a	15.393a	51.913a	90.907a
SE (±)	0.091	0.715	2.546	4.607
No. of seeds/hole				
1	3.056a	14.438a	50.549a	91.387a
2	2.786ab	11.572b	33.825b	75.098b
3	2.635b	11.107b	34.561b	58.558c
4	2.593b	11.153b	29.971b	54.938c
SE (±)	0.105	0.826	2.940	5.320
Varieties				
Kananmado	3.602a	14.307a	43.300a	87.921a
SVU 48	1.933b	9,827b	31.153b	52.069b
SE (±)	0.074	0.584	2.079	3.762

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

Table 11 Interactive effect of seed size and cowpea variety on shoot dry weight of cowpea at 4 and 6 weeks after planting at Samaru in 1987.

	4 weeks after planting		6 weeks after planting	
	Cowpea varieties		Cowpea varieties	
Seed Size	Kanannado	SVU 48	Kanannado	SVU 48
Small	12.886c	10.879d	26.085c	17.522d
Medium	15.637b	12.259c	32.673b	19.151de
Large	19.469a	14.828b	44.892a	24.676cd
SE (±)	0.325		2.080	

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

4.2 Effect of Seed Size and Number of Seeds Planted per Hole on the Yield and Yield Components of Cowpea

4.2.1 Grain yield (kg/ha)

Grain yield was significantly influenced by seed size and number of seeds planted per hole but not by cowpea variety (Table 12).

Planting two seeds per hole produced significantly higher yields (1304.6 kg/ha) than planting one, three or four seeds per hole. Planting three or four seeds per hole, however gave significantly higher seed yields (1172.8 and 1144.3 kg/ha) than planting one seed (924.3 kg/ha) per hole. There was no significant difference in seed yield when three or four seeds were planted per hole, although planting three seeds per hole had a slight yield advantage (1172.8 kg/ha) over planting four seeds (1144.3 kg/ha) per hole.

Large seed se size produced significantly higher seed yield (1433.6 kg/ha) than medium or small sized seeds (1033.7 and 942.2 kg/ha respectively). However, the difference in seed yield between medium and small sized seeds was not significant.

The interaction between seed size and number of seeds planted per hole on the grain yield (kg/ha) of cowpea was significant (Table 13). Irrespective of the small and medium sized seed, one, three and four seeds per hole produced similar yields, whereas with the two seeds per hole the yields were statistically different.

Table 12 Effect of seed size and number of seeds per hole on the grain yield, threshing percentage and percent crude protein of cowpea at Samaru in 1987.

Treatments	Yield (kg/ha) (unthreshed pods)	Yield(kg/ha) (threshed grains)	Threshing %	% crude protein
Seed size				
Small	1410.840b	942.153b	66.779b	23.333a
Medium	1700.680b	1033.720b	65.950b	23.104a
Large	2049.230a	1433.560a	69.956a	23.427a
SE (±)	338.154	47.332	0.994	0.163
No. of seeds/hole				
1	1330.510c	924.256c	69.466	23.821a
2	2010.100a	1304.570a	65.420b	23.463a
3	1795.060ab	1172.830ab	65.336b	23.308a
4	1788.010b	1144.270b	63.997c	23.660a
SE (±)	390.467	54.655	1.151	0.189
Variety				
Kananmado	1541.370b	1108.320a	71.904a	23.287a
SVU 48	1950.470a	1164.640a	62.938b	23.289a
SE (±)	276.102	38.647	0.814	0.133

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

4.2.2 Threshing percentage (%)

Threshing percentage was significantly influenced by both seed size and number of seeds planted per hole as well as cowpea variety (Table 12). Large sized seeds had significantly higher threshing percentage than medium and small sized seeds. One seed planted per hole produced significantly higher threshing percentage than two, three and four seeds planted per hole, while two and three seeds per hole produced significantly higher threshing percentage than four seeds planted per hole. However, there was no significant difference in threshing percentage between two and three seeds planted per hole. Local Kanannado variety had a significantly higher threshing percentage (71.9%) than variety SVU 48 (62.9%).

4.2.3 Crude protein content (%)

Present crude protein was not significantly influenced by seed size and number of seeds planted per hole, as well as cowpea variety (Table 12). Similarly, none of the interactive effects of seed size and number of seeds planted per hole and cowpea variety on crude protein content was significant.

4.2.4 Number of days to first flowering

Number of days to first flowering was not in any way affected by the number of seeds planted per hole (Table 14). However, seed size significantly affected number of days to first flowering. The large sized seeds flowered one day

Table 13: Interactive effect of seed size and number of seeds/ hole on grain yield (kg/ha) of cowpea at Samaru in 1987.

	Number of seeds per hole			
Seed size	1	2	3	4
Small	867.353cd	1064.27bc	842.00d	995.012bcd
Medium	923.842cd	1161.47b	1040.05bcd	1009.54bcd
Large	981.574bcd	1687.97a	1552.46a	1512.24a
SE (±)		94.66		

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

Table 14 Effect of seed size and number of seed per hole on number of days to first flowering, number of days to 50% flowering and number of flowers per plant at Samaru in 1987.

Treatment	No. of days to flowering	No. of days to 50% flowering	No. of flowers/ plant
Seed Size			
Small	52.281a	56.467a	37.326c
Medium	52.344a	56.594a	41.892b
Large	51.219b	55.938a	54.55a
SE (±)	0.277	0.242	1.297
No. of seeds/hole			
1	51.542a	55.917a	49.113a
2	52.083a	56.375a	44.140b
3	52.000a	56.375a	43.790b
4	52.167a	56.667a	41.316b
SE (±)	0.320	0.280	1.497
Variety			
Kananado	62.438a	68.000a	44.212a
SVU 48	41.458b	44.667b	44.968a
SE (±)	0.226	0.198	1.059

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

earlier than medium and small seed sizes. The number of days to first flowering for medium and small seed sizes was not different. The photoperiod insensitive variety SVU 48 flowered much earlier (41 days) than the photoperiod sensitive local Kanannado variety (62 days).

The interactive effects of seed size, number of seeds planted per hole and cowpea variety on number of days to first flowering were not significant.

4.2.5 Number of days to 50% flowering

Both seed size and number of seeds planted per hole had no significant effect on the number of days to 50% flowering, but varietal differences were significant (Table 14). As with the number of days to first flowering, the number of days to 50% flowering was significantly earlier for variety SVU 48, while the local Kanannado variety took longer and number of days to reach 50% flowering.

The interactive effects of seed size, number of seeds planted per hole and cowpea variety on the number of days to 50% flowering were not significant.

4.2.6 Number of flowers per plant

The number of flowers per plant produced was significantly influenced by seed size and number of seeds planted per hole but not by cowpea variety (Table 14).

The number of flowers produced per plant increased with increased seed size. The large sized seeds had the highest number of flowers (54 flowers/plant) while the small sized seeds had the least (37 flowers/plant).

Planting one seed per hole produced significantly higher number of flowers per plant (49 flowers/plant) than planting two, three or four seeds per hole (44, 44, 41 flowers/plant respectively). However, there was no significant difference in the number of flowers produced when either two, three or four seeds were planted per hole.

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

4.2.7 Number of seeds per pod

Number of seeds per pod was not affected in any way by both number of seeds planted per hole and cowpea variety (Table 15). However, seed size significantly affected number of seeds per pod. Large sized seeds had significantly higher number of seeds per pod (10 seeds per pod) than medium (9 seeds per pod) and small sized (9 seeds per pod) seeds. Medium and small sized seeds had similar number of seeds per pod.

The interactive effect of seeds planted per hole and cowpea variety were not significant.

Table 15 Effect of seed size and number of seeds per hole on some yield components of cowpea at Samaru in 1987.

Treatment	No. of seeds/ pod	No. of pods/ plant	No. of seeds/ plant	Wt of seeds/ plant(g)	100 seed weight (g)
Seed size					
Small	9.060c	24.406c	220.672c	38.199c	17.893b
Medium	9.069b	28.719b	258.669b	47.795b	18.216b
Large	9.697a	38.969a	380.200a	71.877a	19.457a
SE (±)	0.154	0.853	9.790	1.233	0.175
No. of seeds/hole					
1	9.358a	32.250ab	302.050a	57.964a	18.975a
2	9.179a	32.583a	302.275a	54.344ab	18.635ab
3	9.238a	29.625bc	276.283ab	51.00dbc	18.352b
4	9.329a	28.333c	265.442b	47.103c	18.123b
SE (±)	0.178	0.985	11.304	1.423	0.202
Varieties					
Kananmado	9.269a	26.875b	251.967b	51.055b	20.289a
SVU 48	9.283a	34.521a	321.060a	54.152a	16.755b
SE (±)	0.126	0.697	7.993	1.006	0.143

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

4.2.8 Number of pods per plant

Number of pods per plant was significantly influenced by seed size and number of seeds planted per hole as well as cowpea variety (Table 15).

The variety SVU 48 produced significantly more pods (34 pods/plant) than local Kanannado variety (27 pods/plant). Also the number of pods per plant increased significantly as the seed size increased. The large sized seeds produced significantly more pods (39 pods/plant) per plant than the medium (29 pods/plant) and small (24 pods/plant) seed sizes. The differences between the other two seed sizes was also significant.

The number of pods per plant decreased significantly when the number of seeds planted per hole increased from one to four. However, planting two seeds per hole gave significantly more pods per plant than when three or four seeds were planted. The differences in the number of pods produced per plant, when three or four seeds were planted per hole was not significant. No matter the number of seeds planted per hole, the large seed size gave the highest number of pods per plant.

4.2,9 Number of seeds per plant

The number of seeds per plant was significantly affected by seed size, number of seeds planted per hole and cowpea variety (Table 15). The highest number of seeds per plant (380 seeds/plant) was obtained when large sized seeds were planted. Infact, there was a significant increase in the number of seeds per plant as seed size increased. The least number of seeds per plant (221 seeds/plant) was obtained when small sized seeds were planted. The medium sized seeds also gave significantly higher number of seeds per plant (259 seeds/plant) than the small sized seeds.

The number of seeds per plant decreased gradually as the number of seeds planted per hole increased. A significantly higher number of seeds per plant (302) and (302.3) seeds/plant was obtained when one or two seeds were planted per hole, than when three or four seeds were planted. Number of seeds per plant was not significantly different when three or four seeds were planted per hole. Similarly, when one, two or three seeds were planted per hole, significantly more seeds per plant (302, 302.3 and 276.5 seeds/plant respectively) were obtained than when four seeds were planted, which produced only 265.4 seeds per plant.

The variety SVU 48 produced significantly more seeds per plant (321 seeds/plant) than the local Kanannado variety (252 seeds/plant).

The interactive effects of seeds size, number of seeds planted per hole and cowpea variety were not significant.

4.2.10 Weight of seeds per plant (g)

Weight of seeds per plant was significantly influenced by the seed size and number of seeds planted per hole as well as cowpea variety (Table 15). There was a significant increase in weight of seeds produced per plant as the seed size increased. The heaviest seed weight per plant (71.9g) was obtained when large seeds were planted, while the least seed weight per plant (38.2g) was obtained when small seeds were planted. The medium sized seeds also gave significantly heavier weight of seeds per plant (47.7g) than small sized seeds.

The weight of seeds per plant decreased as the number of seeds planted per hole increased (Table 15). A significantly heavier seeds per plant (58g) was obtained when one seed was planted per hole, which was not significantly different with two seeds planted per hole. However, the lowest weight of seeds per plant was recorded when four seeds were planted per hole. There was no significant difference in the weight of seeds produced per

per plant when three or four seeds were planted per hole.

Variety SVU 48 produced significantly heavier seeds (54.2g) per plant than the local Kanannado variety (51g).

The interaction between seed size, number of seeds planted per hole and cowpea variety was not significant.

4.2.11 100 seed weight (g)

Weight of 100 seeds was significantly influenced by seed size, number of seeds planted per hole as well as cowpea variety (Table 15). The large sized seeds produced significantly heavier seeds (19.5g/100 seeds) than the medium (18.2 g/100 seeds) and small (17.9 g/100 seeds) seed sizes. However, thedifferences in weight of 100 seeds for medium and small seed sizes was not significant.

The differences in the weight of 100 seeds were marginal whether one or two seeds were planted per hole. However, planting one seed per hole gave significantly heavier seeds (19 g/100 seeds) than planting three or four seeds per hole (18.4 and 18.1 g/100 seeds respectively) There was no significant difference in weight of 100 seeds produced when three or four seeds were planted per hole.

Irrespective of the seed size planted, local Kanannado variety produced heavier seeds (20.3 g/100 seeds) than variety SVU 48 (16.7 g/100 seeds). Similarly, no matter the number of seeds planted per hole, local Kanannado variety produced heavier seeds than variety SVU 48.

4.3 Correlation Analysis

Correlation co-efficients between different growth characters, yield components and yield was done to determine their relationships (Table 16).

There was significant positive correlation between yield and leaf area per plant, stem length (all at 8 WAP), number of flowers per plant, weight of seeds per plant, number of seeds per plant and number of pods per plant.

There was significant positive correlations between leaf area per plant, number of leaves per plant, number of branches per plant and stem length of cowpea (at 8 WAP). There was also significant positive correlation between leaf area per plant and number of flowers per plant, weight of seeds per plant, number of seeds per plant and number of pods per plant. Number of leaves per plant was also positively correlated with number of flowers per plant, number of days to 50% flowering, 100 seed weight and weight of seeds per plant.

Table 16 Matric of co-efficient of correlation(s) between grain yield, yield components and growth of cowpea varieties (Kanannado and SVU 48) at Samaru in 1987.

	1	2	3	4	5	6	7	8	9	10	11
1	1.00										
2	0.335**										
3	0.090	-0.038									
4	0.471**	0.689**	-0.121								
5	0.024	0.225	0.810	0.248*							
6	0.483**	0.776**	-0.368**	0.737	-0.068						
7	0.454**	0.773**	-0.440**	0.726**	-0.117	0.461**					
8	0.250*	0.429**	0.105	0.440**	0.330**	0.363**	0.382**				
9	0.199	0.335**	0.574**	0.390**	0.695**	0.169	0.122	0.681			
10	0.182	0.326**	0.612**	0.375**	0.731**	0.126	0.075	0.350**	0.705**		
11	0.262*	0.470**	0.443**	0.498**	0.603**	0.162	0.269*	0.509*	0.661**	0.519**	1.00

NB: * significant at 5% level of significance; ** significant at 1% level of significance.

1 Grain yield (kg/ha)
2 No. of flowers/plant
3 No. of days to 50% flowering
4 Weight of seeds/plant
5 100 seeds weight (g)
6 No. of seeds/plant
7 No. of pods/plant
8 Leaf area/plant at 8 WAP
9 No. of leaves per plant at 8 WAP
10 No. of branches/plant at 8 WAP
11 Stem length (cm)

The number of flowers per plant, number of pods per plant, number of seeds per plant were significantly and positively correlated with each other. The number of days to 50% flowering was however, significantly but negatively correlated with the number of seeds and number of pods per plant, but was significantly and positively correlated with number of leaves and number of branches per plant as well as plant height (at 8 WAP).

Chapter 5

DISCUSSION

5.1 Effect of Seed Size

5.1.1 Growth characters

The results obtained in this study revealed that, large sized seeds had significantly higher percentage germination than small sized seeds. This observation is in agreement with general findings of Harper and Obied (1967) in flax, Sivasubramanian and Ramakrishnan (1974) in groundnuts, Lamido (1987) in winged beans and Clark and Peck (1968) in snapbeans. The superiority of large sized seeds was probably because they had more carbohydrate, total protein and amino acids reserves in their cotyledons. This is an indication that large sized seeds possess better germinability and higher viability potential than small sized seeds.

The emergence of seedlings, their early vigour and and growth seem to be related to the food reserves in the seeds. Stem length, leaf area, number of leaves, number of branches per plant as well as shoot dry weight per plant significantly increased with increase in seed size. These increases indicate a more vigorous growth and a higher photosynthetic capacity of plants from large sized seeds. compared with those from small sized seeds. This is in conformity with the findings of Burris et al (1973)

in soybeans and Dhillon et al. (1977) in mung beans who observed that large sized seeds had higher number of leaves, branches and total leaf area per plant as well as shoot dry weight per plant than small sized seeds. Furthermore, plants from large seed size become established faster as evidenced by the number of leaves and branches per plant as well as total leaf area per plant (20, 4, 976.45 cm^2 respectively) at 4 weeks after planting. Comparable figures when small sized seeds were planted were 12, 2 and 463.4 cm^2 for number of leaves, branches and total leaf area per plant respectively at 4 weeks after planting. This shows that canopy development for large sized seeds was faster at the early stage of growth than small sized seeds. When canopy is less than full cover, solar radiation escapes interception by photosynthetic apparatus and the dry matter production is directly related to the fraction of light intercepted, as evidenced by the high shoot dry weight produced by large sized seeds at 4 weeks after planting. This has been indicated by Shibles and Weber (1965) and Williams et al. (1965a) who found that, when cover is scanty, production is directly related to the fraction of light intercepted. The result is similar to the findings of Black (1956) in subterranean clover who reported that, the significance of seed size depends on the direct relationship between seed size and cotyledons area, the larger the seeds,

the greater the initial photosynthetic area which resulted in more dry matter accumulated in large sized seeds than in small sized seeds. The results obtained in this study is also supported by the findings of Dhillon and Kler (1976) who reported that, the growth and yield of the resulting plants were proportional to their initial "Food capital" following "compound interest" law.

Dry matter production increased with increase in seed size with larger seeds showing significantly higher increases than small sized seeds. This increase in dry matter production is 25% and 35% for medium and large sized seeds respectively when the seed size was increased from small to medium and from medium to large sized seeds, at 4 weeks after planting. This result agrees with the conclusion reached by Blackman (1919) that dry matter attained at any period of time by an annual plant depends on its initial seed weight.

5.1.2 Yield and yield components

The significant increase in total grain yield, number of pods, number of seeds, seed weight per plant, number of seeds per pod and 100 seed weight with increasing seed size is quite similar with results obtained by Burris et al. (1971), Fontes and Ochlrogge (1972), Burris et al.

(1973) and Smith and Camper (1975) in soybeans, in which grain yields, number of pods and number of seeds per plant increased with increase in seed size. Large sized seeds had higher seedling vigour than small sized seeds. Seedling vigour can persist throughout the life cycle of the plant and be expressed in crop yield (Brenchley, 1923). The high yield obtained could be attributed to the more vigorous growth and higher photosynthetic capacity of large sized seeds than small sized seeds. Vigorous vegetative growth enhanced efficient photosynthetic activities of the crop. The resulting photosynthates are thus translocated to the storage sinks for grain development and high grain yield in cowpea (Summerfield, et al., 1985).

5.2 Effect of Number of Seeds per Hole

5.2.1 Growth characters

Plant growth parameters, such as, number of leaves, number of branches, leaf area and shoot dry weight were significantly influenced by the number of seeds planted per hole. All these growth parameters showed a decreasing trend with increase in the number of seeds planted per hole. Other growth parameters such as percentage germination and stem length were not significantly influenced by the number of seeds planted per hole. However, stem length increased with increasing number of seeds planted per hole. Four

seeds planted per hole gave taller plants than when one, two or three seeds were planted. This could be due to high inter-plant competition for light and environmental resources which resulted in taller plants. This is in agreement with the findings of Ojehomon and Bamiduro (1971) who reported that the average stem length increased with density, so that at highest densities the plants were very tall and spindly. The insignificant difference in stem length could be attributed to the thinning of the crop to two plants per stand which prevented further intra- and inter-plants competition.

Percentage germination was not affected by the number of seeds planted per hole. This might be due to the inherent capacity of the crop to germinate and favourable environmental factors at the time the seeds were planted, which resulted in uniform seed germination. However, higher germination count was recorded (79.47%) per hole than when three, two and one seed were planted (74.3, 73.9, and 72.7 percent respectively) though not significant. This could be attributed to the increase in sound seeds as the number of seeds planter per hole was increased.

Number of leaves, number of branches, leaf area and shoot dry weight per plant decreased with increase in number of seeds planted per hole. The decrease in these

parameters with increased number of seeds planted per hole could be attributed to the increase in intra and inter-plant competition for space, light, soil moisture and nutrients as the number of seeds planted per hole increased. One seed planted per hole had higher number of branches, leaves, leaf area and shoot dry weight than two, three and four seeds per hole. This could be because one seed planted per hole was not subjected to any sort of competition, it had all the environmental requirements for full expression of its genetic potential. The insignificant differences in the number of leaves, branches, leaf area and shoot dry weight when two, three and four seeds were planted could be attributed to the thinning of three and four seeds planted per hole to two plants per stand at 4 weeks after planting.

The number of branches produced per plant also decreased as the number of seeds planted per hole increased. This could be due to intra- and inter-plant competition which suppressed the branch buds from developing before the plants were thinned to two plants per stand and the effect lasted throughout the life cycle of the crop. This is similar to the findings of Ojehomon and Bamiduro (1971) who reported that branch buds of cowpea were suppressed and latter shed with increased densities, consequently, the plants looked trimmed at high densities.

5.2.2 Yield and yield components

Grain yield and yield components of cowpea were significantly influenced by number of seeds planted per hole. Two seeds planted per hole had significantly higher grain yield than four and one seed planted per hole. However, two seeds planted per hole was not significantly different from three seeds planted per hole. Two seeds planted per hole gave 29 and 12 percent yield advantage over one and four seeds planted per hole respectively. The yield advantage of two seeds planted per hole over one seed planted per hole could be attributed to lower plant population in one seed planted per hole than in two seeds planted per hole. However, the yield advantage of two seeds over four seeds planted per hole could be attributed to high plant population in four seeds planted per hole, which resulted in intra- and inter-plant competition for space, light, moisture and nutrients before the plants were thinned to two plants per stand.

The insignificant difference in grain yield when two and three seeds were planted per hole could be due to the fact that the time the plants were thinned to two plants per stand, the three seeds planted per hole had enough space and therefore, did not start competing for light, moisture and nutrients. This might have resulted in negligible yield differences between the two number of seeds planted.

The results are similar to the findings of Ojehomon and Bamiduro (1971) who reported that, yield of cowpea were lowest at higher plant densities due to intra and inter-plant competition for space, light, soil moisture and nutrients.

Planting one or two seeds per hole produced significantly higher number of pods, seeds, and weight of seeds per plant as well as 100 seed weight than three or four seeds planted per hole. This could be, because the one seed planted per hole was not subjected to any sort of competition. It has all the environmental resources for full expression of its potential. However, the difference in the number of pods, number of seeds, weight of seeds per plant and 100 seed weight were not significant when three and four seeds were planted per hole. The insignificant difference in the number of pods, number of seeds, weight of seeds per plant and 100 seed weight could be attributed to the intra- and inter-plants competition for space, light, moisture and nutrients which resulted into reduction of numbers of leaves, and leaf area per plant at the early stage of plant growth before they were thinned to two plants per stand. As the yield of any agricultural crop is dependent on the size and efficiency of its photosynthetic system (Loomis and Williams, 1963) which is determined during the vegetative growth of the crop. Anything that

results in the reduction in the vegetative growth of the crop, will result in the reduction in yield and yield components of the crop.

5.3 Effect of Variety

5.3.1 Growth characters

Stem length, number of leaves, number of branches, leaf area and shoot dry weight per plant were all significantly influenced by cowpea variety. The significant effect of variety on these growth characters, may be explained by the fact that, these characters are genetically controlled, although they can also be influenced by environmental factors (Anon. 1985). The local Kanannado variety performed better than SVU 48 in all the growth characters measured. The variety was taller and had higher number of leaves, branches and leaf area per plant as well as shoot dry weight than variety SVU 48.

5.3.1 Yield and yield components

The results obtained in this study, revealed that, cowpea grain yield was not significantly affected by cowpea variety, eventhough number of pods, number of seeds per plant and 100 seed weight were significantly influenced cowpea variety. Variety SVU 48 produced significantly higher number of pods and seeds per plant (22 and 21.5 per cent respectively) than local Kanannado variety. However,

local Kanannado variety produced heavier seeds than SVU 48 (17.4 percent). This might bring about the insignificant difference in the grain yield between the two varieties.

5.4 Effect of Interactions

Number of leaves, leaf area, shoot dry weight per plant and stem length were significantly influenced by the interaction between seed size and cowpea variety. Local Kanannado variety produced significantly higher number of leaves, leaf area, shoot dry weight and taller plants than SVU 48 variety with all the seed sizes tested. This probably shows, the predominance of local Kanannado variety over variety SVU 48 in terms of vegetative growth. It was also observed that, irrespective of the variety planted, large sized seeds had higher number of leaves, leaf area, shoot dry weight per plant and taller plants than small sized seeds. This was as a result of more vigorous growth of seedlings from large sized seeds than those from small sized seeds.

The interaction between number of seeds planted per hole and cowpea variety significantly influenced number of branches per plant at 10 weeks after planting. A higher number of branches was observed for the local Kanannado variety irrespective of the number of seeds

planted per hole. Local Kanannado variety produced significantly higher number of branches than variety SVU 48 when one, two, three and four seeds were planted (54. 52, 57.5 percent respectively).

The interaction between seed size and number of seeds planted per hole significantly influenced cowpea grain yields. Large sized seeds had significantly higher grain yields than small sized seeds when one, two, three and four seeds were planted per hole (11.6, 36.9, 45, 34 percent, respectively). This shows that, irrespective of the number of seeds planted per hole, large sized seeds produced significantly higher grain yield than small sized seeds. These results are in conformity with findings of Smith and Camper (1975) and Burris et al. (1973) who reported higher grain yields of soybeans from large sized seeds than from small sized seeds under their different test conditions.

5.5 Correlation

The significant positive correlation observed between grain yield and growth characters such as leaf area, number of leaves per plant and stem length may be attributed to the fact that, these vegetative characters directly determined the amount of photosynthates available for plant growth and grain development. Vigorous vegetative growth

enhanced efficient photosynthetic activities of the crop. The resulting photosynthates are thus translocated to the storage sink for grain development. Stem length was significantly correlated to grain yield, probably because in stem length expose the plants to greater solar radiation for photosynthesis. This was further confirmed by the highly significant and positive correlation of stem length to number of leaves, and leaf area per plant, all of which are important determinants of photosynthates accumulation and hence high crop grain yield. This agrees with findings of Black (1956) in subterranean clover and Fehr and Probst (1971) in soybeans who reported positive correlations between grain yield and leaf area and plant height. A highly positive correlation between plant height and grain yield of cowpea have also been reported by Singh et al. (1982).

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

Chapter 6

SUMMARY AND CONCLUSION

A field experiment was conducted at the Institute for Agricultural Research farm Samaru during the 1987 wet season to investigate the effect of seed size and number of seeds planted per hole on the growth and yield of two cowpea (Vigna unguiculata (L.) Walp) varieties.

The treatments consisted of two varieties (Kananmado (local) variety and SVU 48), three seed sizes (large, medium and small) and four number of seeds per hole (1,2,3 and 4 seeds per hole). These were factorially combined and laid out in a randomized complete block design with four replications.

Cowpea growth characters, yield and yield components increased significantly with increase in seed size. Large sized seeds had significantly higher percent germination, number of leaves, number of branches, leaf area and shoot dry weight per plant as well as taller plants than small sized seeds. They produced significantly higher number of flowers, pods, seeds per plant, weight of seeds per plant, 100 seed weight, number of seeds per pod and higher grain yield than small sized seeds.

Total leaf area per plant, number of leaves per plant, shoot dry weight per plant, yield and yield components, such as number of pods, number of seeds and

weight of seeds per plant were significantly influenced by the number of seeds planted per hole. One seed planted per hole had higher number of leaves, branches, leaf area, shoot dry weight per plant and number of pods, seeds, weight of seeds per plant and 100 seed weight than three and four seeds planted per hole but not significantly different from two seeds planted per hole. However, two seeds planted per hole produced higher grain yield than one and four seeds planted per hole. The number of seeds per pod, percent germination and stem length were not significantly affected by number of seeds planted per hole. However, four seeds planted per hole had higher germination percent and taller plants, while one seed planted per hole produced higher number of seeds per pod.

Varietal effects on the growth and yield of cowpea were highly significant. Local Kanannado variety was more vigorous in vegetative growth than the SVU 48. It produced higher number of leaves, branches, leaf area and shoot dry weight and heavier seeds than SVU 48. On the other hand, SVU 48 produced higher number of pods and seeds per plant than local Kanannado variety. It also outyielded the local Kanannado variety by 4.8% in grain yield, though the difference was not significant.

The interactive effects of the seed size and cowpea variety significantly influenced stem length, number of leaves, leaf area and shoot dry weight per plant. Local

Kanannado variety was significantly taller, had higher number of leaves, branches, leaf area and shoot dry weight per plant than variety SVU 48 irrespective of seed size. On the other hand, large sized seeds had significantly higher number of leaves, branches, leaf area, shoot dry weight per plant and taller plants than small sized seeds irrespective of the variety planted. The interactions between the number of seeds planted per hole and cowpea variety significantly influenced number of branches at 10 weeks after planting. Irrespective of number of seeds planted per hole, local Kanannado variety had higher number of branches than variety SVU 48.

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

Based on these findings, it can be concluded that yield benefits can be obtained from the use of large sized seeds. There is also the possibility of getting high yields from planting two sound seeds per hole than one, three and four seeds per hole and later thin to two plants

per stand. It may, therefore, not be necessary to spend extra time and resources to thin, if two cowpea seeds are sown per hole.

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

Soil composition	Soil depth in cm 0-15	15-30
Texture (%)		
Sand	62.8	55.6
Silt	27.6	26.4
Clay	9.6	18.0
Textural class	sandy loam	loam
Chemical properties		
pH in water	5.3	5.4
pH in 0.01M $CaCl_2$	4.9	5.0
Organic carbon (%)	0.35	0.29
Total nitrogen	0.25	0.20
Available P (ppm)	2.63	0.98
Exchangeable cation(meq/100g of soil)		
Mg	0.88	0.88
Ca	2.84	2.85
K	0.18	0.19
Na	0.05	0.05
Cation exchange capacity (mew/100g of soil)	5.44	7.04

Appendix 2: Total rainfall, mean temperature and relative humidity and sunshine hour hours at ten days' intervals during 1987 wet season.

Month	Days	Rain-fall (mm)	Temperature (°C) max.	min.	Relative humidity(%) a.m.	p.m.	Sun-shine (hours)
May	1-10	Nil	38.7	21.3	36.0	10.7	9.9
	11-20	Nil	38.6	23.4	47.7	16.8	8.1
	21-31	135.7	33.4	22.0	66.6	45.6	8.5
June	1-10	85.4	29.8	20.6	81.5	63.5	6.4
	11-20	8.2	32.1	21.8	71.2	53.8	8.9
	21-30	45.1	30.1	21.0	76.7	68.2	7.5
July	1-10	52.3	30.5	20.6	77.6	61.7	8.4
	11-20	102.4	30.6	20.3	78.9	64.3	7.9
	21-31	118.0	29.2	19.7	82.6	68.6	6.8
August	1-10	105.4	29.9	19.9	83.0	67.7	7.0
	11-20	75.2	28.5	19.2	86.6	76.6	5.1
	21-31	85.4	29.2	20.4	86.5	72.8	6.1
September	1-10	33.0	29.9	20.4	78.7	64.8	8.0
	11-20	57.1	30.4	20.4	75.9	65.6	7.1
	21-30	12.0	31.0	20.3	73.2	59.1	8.9
October	1-10	42.6	30.8	20.0	73.4	57.1	8.0
	11-20	Nil	31.4	18.7	62.6	47.3	9.4
	21-31	Nil	30.9	14.1	28.4	28.8	8.3

Source: Meteorological Unit, Institute for Agricultural Research, Ahmadu Bello University, Samaru Zaria, Nigeria.

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