GROWTH AND YIELD PERFORMANCE OF FOUR GROUNDNUT VARIETIES IN RESPONSE TO SEED SIZE

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CHAPTER ONE

1.0 INTRODUCTION

The causes of Africa's food problem are diverse and yet interrelated and increasing food production is a central part of the food security challenge in Africa (Eicher, 1987). Seed is a primordial input for crop production and it is the embodiment of past harvests as well as the promise of future ones (Tripp, 1995). Seeds are regarded as farmers' most precious inputs. The seed is the forerunner of the next generation in the life of a plant and high-quality seed is an important prerequisite for a high crop yield. Only high quality seed will produce strong plants which are resistant to disease and adverse conditions (FAO, 1981). The seed habit in plants has developed over a long period of time and represents the highest type of plant development (Stanton, 1985)

Seed size has a significant influence on the future performance of the seedling. Within species, larger seeds tend to give faster emergence and produce larger seedlings. In general, however, if seed spacing adopted allows plants to express their potential in full, larger seeds give considerable increase in yield in comparison with smaller seeds (Forbes and Watson, 1992). Seed size or weight of plants varies and reflects in the seedling under uniform conditions, but there are no lasting advantages to the seedling regardless of the size of the seed from which it was produced. Furthermore seeds of identical size and weight give rise to seedlings differing widely in size. Forbes and Watson (1992) noted that seed size is correlated positively with seedling size, but then not with inherent vigour of the plant so that grading the seed would not make a more, vigorous stock. The seed supplies energy for germination and differentiation of the embryo, the development of the plant until the synthetic mechanism can become established. The effect of seed size is not masked by independent growth of the groundnut seedling during the growing season.

Small seeds are weaker and more vulnerable than large seeds (Dupriez and De leener, 1988). Large seed size will usually be advantageous for better vigour on account of the greater amount of nutritive substances, while small seed size is typical of certain varieties and do not then constitute a disadvantage. On the whole, a large, heavy seed has a greater nutritive reserve and usually produces strong seedlings with satisfactory development. The young plant has to live on the nutritive substances contained in the seeds.

The size and shape of seeds is extremely variable. They depend on the form of the ovary, the amount of assimilates partitioned into the seed, the condition under which the parent plant is growing during seed formation, and obviously the species (Tindall, 1983). According to Tindall (1983), the factors which determine the size and shape of seeds are the size of embryo, amount of endosperm present and to what extent other tissues participate in the seed structure. For groundnuts, larger seeds show high germination rates, vigorous growth and high yield (Knauft *et al.,* 1990). Vindhavarmann *et al.* (1990) and Detroja *et al.* (1993) reported that groundnut plants from larger seeds outyielded plants from smaller seeds due to an increased proportion of effective pods and consequently pod yields. Westoby *et al.* (1996) observed that larger seeds contain more mineral nutrients and carbon-based reserves than small seeds. They also reported that young seedlings from large seeds are more likely to tolerate adverse conditions as such seeds are able to establish better in the shade, under drought when buried beneath soil or litter and established vegetation.

Another situation where large seed size or mass might be an advantage is in poor nutrient soils although this has received little attention (Stock *et al.*, 1980). Jurado and Westoby (1992) reported that large-seeded species tend to survive longer in the absence of enough soil nutrients. Seed size is usually small in species from disturbed habitat which exhibit high levels of dispersal in time and space. The early growth of large-seeded species may be less affected by the level of soil nutrients (Lamont and Milberg, 1977). Sahoo *et al.* (1988) and Sedano *et al.* (1988) recorded no such advantage in yield with large seeds, while Detroja *et al*. (1993) also reported that differences in size did not influence plant height, number of branches per plant or shelling percentage.

Small seed size according to Shitting (2002), would germinate readily and produce normal plants even though the grain size might be only one-tenth that of the large size grain. He further observed added that the growth rate of the plant from small seed was higher than that of plants from normal seed size but all size of seed tend to attain the same final size.

The embryo weight is proportional to seed weight so the effect is not due to a relatively larger embryo in the small seed. Differences in seed size show differences in growth. This advantage is manifested from the very start as large seeds have larger cotyledons, producing positive feedback for, these capture more light and leads to faster growth and elongation. A positive relationship between cultivar seed size and yield has been reported (Le Roy *et al.*, 1991; Tinius *et al.*, 1991). These variable results imply that the growth and yield response to seed size at planting cannot be generalized and specific recommendations are required for different genotypes and environments. Farmers are often advised to select large and well-filled seeds for planting; but in many developing countries supply of seeds are limited and farmers often have no alternative than using seeds of lower quality. It is now becoming increasingly appreciated that successful vegetable production is very dependent upon a supply of satisfactory seed (Raymond and George, 1985).

Large scale cultivation could not be implemented until the problem of poor germination, emergence of seed and poor yielding varieties occurring frequently has been solved.

Little attention has been recorded on impact of size of seed on yield of edible legume such as groundnut in the country.

The objective of this study was, therefore, to determine the influence of seed size on growth and yield of four groundnut varieties.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and distribution of groundnuts

Groundnut (*Arachis hypogaea* L.) is a cultivated annual of South American origin, domesticated in the broad area between Brazil, Argentina, Paraguay, Peru and Bolivia (Tweneboah, 2000). Unknown outside the New World in pre-Columbus times, groundnut was first taken to the West Coast of Africa by the Portuguese in the 16th century, while the Spanish took it to the Philippines from Peru. According to Purseglove (1998), groundnut was taken across the pacific to the Philippines by the Spaniards before spreading to Asia.

Before the arrival of the first Europeans in South America, groundnut was already cultivated by the Incas in Peru and from there it spread to Mexico and the West Indies before the Portuguese imported it, especially the prostrate or so-called running type into West Africa (Waele and Swanevelder, 2001). They stated that its introduction into West Africa and for that matter Ghana, is gradually replacing traditional bambara groundnuts.

Tweneboah (2000) reported that out of 6 million tonnes of groundnuts produced in Africa about 80% comes from the savanna zone to the south of the Sahara and only 5% from the analogous zone in the Southern Hemisphere. He stated Nigeria, Senegal, Niger and the Sudan as the four largest producers in this zone. India is by far the largest world producer, others include China, U.S.A, The Gambia, Mali and Malaysia.

All other species of the genus *Arachis* are wild and occur only in South America where they use as forage (Waele and Swanevelder, 2001). It has also been reported that most of the produce is consumed locally.

2.2 Botany and morphology

Arachis hypogaea L. belongs to the family *Leguminosae* and sub-family *Papilionoideae* (Waele and Swanevelder, 2001). They also stated that the botanical name of groundnut is derived from the Greek *arachis* meaning 'legume' and *hypogaea* meaning 'below ground', referring to the formation of pods in the soil. Like the bambara groundnut of West Africa, all species of *Arachis* are geocarpic, opening their fruits underground and the plant is cultivated in tropical and sub tropical regions all over the world as well as warm temperate regions (Kochhar, 1986).

According to Tweneboah (2000), groundnut is an annual herb whose main and remarkable characteristic is the production of fruits underground. He reported that it is unique in that, after fertilization, the aerial flowers grow downwards and the ovary, at the end of the elongated stalk 'peg', enters the soil in a positive geotropic manner where the ovary at the tip of the peg grows into the pod containing seeds. The plants has a tap root with, abundantly branched, lateral roots on which globular, often dark brown nodules are usually present but branching and floral axis patterns are two discriminating characters (Gregory and Gregory, 1986).

There are two distinct botanical types of cultivated groundnuts:

(a) Virginia type (late maturity) in which the plants have pods dispersed along the secondary and tertiary branches and the seeds possess appreciable fresh dormancy with alternate branching patterns i.e has many apical meristems and densely, bushy appearance.

(b) Spanish Valencia (early maturing) in which the plant is generally erect, has pods clustered about the base of the plant while the seeds possess little fresh dormancy (Litzenberger, 1976). The crop grows to a maximum height of 60cm and is strictly an annual legume with yellow flowers appearing (4-6 weeks) after planting and soon after fertilization; the ovary generates a peg forming the pod with 1-6 seeds surrounded by a thick fibrous shell.

Waele and Swanevelder (2001) reported that a mature pod consists of an exo-, meso-and endocarps covering one to seven seeds but the pods are cylindrical in shape with a beak and light constriction between seeds.

2.3 Some uses of groundnuts

According to Kochhar (1986), green haulm of groundnut make excellent fodder and the lower grade oil from the feed also used in the manufacture of soap, lubricant and illuminants.Groundnut also called peanut, is used as food boiled and salted to improve flavour and taste,used as butter, eaten alone and in sandwiches or mixed into candies, cookies, pies and other bakery products (World Book of Encyclopedia, 1990). In Africa, they are eaten fresh, boiled or grilled and also in the preparation of soup (Waele and Swanevelder, 2001). The paste obtained after the oil has been extracted is also moulded into different shapes and fried as "Krukli". It is used to make a synthetic textile fibre, 'ardil' from groundnut protein as the fibres have wool-like texture (Kochhar, 1986). Oils of groundnuts are used as ingredient in face powders, shaving creams, shampoos and paints. They are also used in making nitroglycerin (an explosive). The residue after oil extraction is a high-protein livestock feed. Groundnuts can also be used as cake, flour, peanut protein, and peanut milk for, human consumption. Medicinally, the oil of groundnut is used as a laxative and emollient (Abbiw, 1990).

2.4 Ecology

Most of the crop is produced in regions with an annual rainfall of 400mm or more under low evaporative demand but there is a minimum requirement for 200mm during the growing season although this is greater in soils that do not store winter rainfall (Gibbon and Pain, 1985). A good rainfall distribution during the vegetative period of growth will encourage adequate flowering and proper development of the nuts (Tweneboah, 2000). Kochhar (1986), indicated that enough rainfall of 500 to 1000mm per year to ensure high respiratory exchanges during pod formation and vegetative period of growth. On ideal temperature for groundnut, Tweneboah (2000) reported 24-30°C, but a minimum of 12-15°C is required for germination and at least 24°C is necessary for flowering and seed setting.

Groundnuts usually grow well in light sandy to sandy-loam, well-drained, aerated soil but heavy soils or soils with a tendency to form crust are unsuitable because they hamper the penetration of the pegs during flowering and impact negatively on harvesting (Waele and Swanevelder, 2001). Hack (1970) observed that heavy clay soils make harvesting difficult, reduce yield through fracture and pod may be strained by adhering clay. Interestingly, groundnuts will grow in heavier soils according to Tweneboah (2000) if there is no water-logging and if the surface soil is loose enough to allow penetration of the ovary. Farmers have general preference for well drained, light sandy loams because of ease of cultivation and harvest.

2.5 Nodulation effect on growth and yield

Groundnuts, like other leguminous crops produce nodules on roots which host rhizobium bacteria, which fix atmospheric nitrogen for their use (Tweneboah, 2000). The ability of legumes to add nitrogen to the soil is of considerable practical importance in the maintenance of soil fertility in the tropics. Duke (1981) stated that any area of land that has been planted with groundnut in previous seasons, presumably has enough *Bradyrhizobium* population to facilitate effective nodulation. The proper culture of rhizobium bacteria is often a wise insurance policy recommended in virgin soils or area where groundnuts have not been grown before. In. contrast, inoculation with rhizobium does not always lead to yield increase (Gaur *et al.*, 1974).

In the tropics groundnuts are seldomly inoculated because they nodulate effectively (Gaur *et al.*, 1974) with the naturalized cowpea strains found in most tropical soils. According to Nambiar and Rao (1986), groundnuts may fix as much as 190kg nitrogen per hectare. The rhizobial bacteria which live inside the nodules fix nitrogen through a symbiotic association (Tweneboah, 2000). He stated that the bacteria enter the roots of their host through the root hairs and receive their energy just as the legume receives nitrogen fixed by the bacteria for growth.

2.6 Cultivation and management

Management and cultivation recommendations are dependent on whether the groundnut is grown with cotton, vegetables, root crops or as the sole crop (Gibbon and Pain, 1985). However, seeds should be kept in the shell until as near to the time of planting as possible since viability declines rapidly after shelling and the testa is easily damaged. Whole pods or more commonly, decorticated seeds are used for raising the crop (Kochhar, 1986).

Again, both hand shelling and machine shelling are possible although the greater damage caused by mechanical shelling has resulted in the recommendation that such seed should be treated with a mercurial or thiram dressing. Planting can sometimes be done using whole pod but germination is often slow and uneven and the possibility of including diseased and damaged seeds is very high (Waele and Swanevelder, 2001). Increasing plant population causes a reduction in all yield components per plant but number of pods and seed weight per pod are reduced more than individual pod weight. For maximum yield, it is best to plant early in the growing season and also to reduce the high disease risk from rosette and leaf spot (Gibbon and Pain, 1985).

According to Tweneboah (2000), the following planting procedure should be observed: Depth of sowing-5-7cm; spacing between line-40cm, 50cm or 60cm according to variety; spacing in the lines-15-30cm; maturity- 90days (early varieties), 105 days (intermediate varieties) and 120days (late varieties), its seed rate of 30kg/ha-40kg/ha of shelled seed or sufficient seeds to give a plant population of 100,000-150,000 plants/ha at 2-3 seeds per hill depending on the variety (bunch or runner) is recommended.

Most groundnuts are grown on sandy soils, often of poor fertility and their response to fertilizer is usually about unpredictable therefore nodulation which is effective about 3 weeks after planting, should provide sufficient nitrogen for the plant's requirements although a small quantity of nitrogen can be applied for early growth stages (Gibbon and Pain, 1985). They also stated that, in unfertilized soil, legumes fix more atmospheric nitrogen as nodules develop abundantly but when fertilizers are used to enrich the soil in nitrogen, the plant fixed little atmospheric nitrogen; there are few nodules.

Good soil preparation is essential for good yield (Waele and Swanevelder, 2001). They also reported that deeply ploughed land also facilitates root penetration. Heavy clay soils make harvesting difficult, reduced yield through peg fracture and pod may be strained by adhering clay (Hack, 1970). Groundnuts according to Tweneboah (2000) respond to phosphatic fertilizers because phosphorus affects the rate of nitrogen fixation. He stated that, single superphosphate has been shown to give better results than other forms of phosphatic fertilizers due to high content of sulphur and calcium, both of which are important in groundnut nutrition.

2.7 Environmental and genetic influences on seed size

The size of any legume seed may be due to either environmental or genetic factors, or both combined (Marrewijk and Louwaars, 1992). Again, they observed that genetic seed quality therefore is determined by those plant characteristics resulting from the genetic potential of the embryo and genetic variation within a seed lot. With the seed as a major sink of metabolism, during reproductive phase of groundnut development, it represents the combined effect of many environmental and genetic influences. Manifestation of genetic potential is influenced by agronomic practices and ecological and characteristics of the site where the seed is planted (Marrewijk and Louwaars, 1992). Again, they stated, yield-determining components such as plant architecture, pest and diseases resistance, harvest index, culturally-important characteristics such as colour and taste of the commercial product are to a large extent, genetically controlled.

Yield of common seed has been negatively associated with cultivar seed size (White and Gonzalez, 1990). Seed size is known to be a genetic characteristic of a genotype. According to Burton (1987), genetic rather than environmental influences are more important heritability estimates for seed size are usually 44% to 94% on a plot mean basis. In contrast, White and Gonzalez (1990), Le Roy *et al*. (1991) and Tinius *et al*. (1991) reported a positive relationship between cultivar seed size and yield. The environment during seed ripening could affect the vigour of the seedling as reported by Kidd and West (1991) on earlier trials made. They concluded that conditions of the environment may indirectly affect the seed because of an influence on the plant itself or directly affect the seed because of its position on the plant.

According to Tweneboah (2000), a good environmental condition during the vegetative period of growth encourages adequate flowering and proper development of seed. The negative relationship of yield potential of cultivar and seed size of beans appears contrary to the observation made on plants originating from small seed. It is suggested that some genetic factor associated with large cultivar seed size rather than large seed size itself may be responsible for the lower yield of larger seed varieties.

2.8 Effect of leaf and canopy size on growth

Leaf canopy fulfills a role of intercepting solar radiation (Hay and Walker, 1989), and as such it was important for crops to be grown such that the annual cycle of leaf area index will match the seasonal variation in incident solar radiation so that potential yield will not be lost. In studies of individual leaves of temperate species, the rate of net photosynthesis increases with irradiance (Monteith, 1981). In contrast, the photosynthetic efficiency of the leaves (i.e quantum yield) appears to decrease continuously with increasing irradiance because above point of saturation, further increments of photosynthetically active radiation (PAR) give no increase in the rate of net photosynthesis (Hay and Walker, 1989). They observed that optimum canopy architecture will lead to high rates of canopy photosynthesis and crop growth. He added that canopy architecture can have important implication for assimilate partitioning and harvest index.

Additional input of solar energy to the leaf surface serves only to increase the energy load to be dissipated by transpiration, re-radiation and convection, and to increase the risk of thermal stress. Leaflessness either by seasonal, or less regular, leaf fall at the onset of severe water stress, or as a permanent feature, relying upon photosynthetic stem tissue affect growth (Gardner *et al.,* 1985). According to Mansfield and Davies (1981), the closure of leaf stomata is the most important process in plant protection from exposure to severe water stress in order to improve growth and yield.

2.9 Effect of seed size on establishment

Optimum groundnut production relies upon a number of environmental and cultural parameters. Of these parameters, a rapid and uniform stand establishment is basic to vigorous seedlings and plant performance. Of the variables affecting stands establishment and plant performance seed size is one trait that can easily be manipulated and may be of economic importance. The basic tenets of these reports are;

a) A larger endosperm enhances emergence ability.

b) Larger cotyledons are capable of higher photosynthetic rates.

Edwards and Hartwig (1971) in their study on effect of seed size upon rate of germination in groundnuts realised that the small seeded lines germinated more rapidly than the large seeded at each moisture level. Rapid germination in field plantings will usually reduce the hazards of obtaining uniform stands. It appears that cultivars having average seed sizes of 9 to 10g per 100 seeds would be useful for reducing problems in obtaining uniform stands when plantings are made on clay soils.

Fehr and Probst (1971) observed that the inhibition of hypocotyls elongation might in part be magnified by increased soil resistance. The smaller the seed size the less resistance to planting media during emergence. Larger seed size has been associated with slower field emergence (Edwards and Hartwig, 1971; Hopper *et al.*, 1979).

However, adaptive interpretation of between species differences in seed mass, several excellent earlier reviews summarized by Westoby *et al. (*1992) are based on the concept of a seed-number trade off, expressed graphically by Smith and Fretwell (1974). This proposes that smaller seeds can be produced in greater numbers than larger seeds from a given quantity of material resources available for investment in offspring. Seed size therefore evolves as a compromise between these counter-posed selection pressures. More particularly the best compromised seed size is expected to depend on how much a seedling chances of establishing are improved by having more resources available to it, and thus relationship can be expected to depend on the environmental circumstances under which seedlings are establishing and on physiological and other attributes of the plant species (Foster, 1986). Seedling developing from small (less than 80mg) or large (greater than 220mg) seeds may have reduced vigour (Burris *et al.*, 1971). Within normal range of seed size, cultivar is more important than seed size in determining emergence (Johnson and Leuders, 1974).

2.10 Effect of seed size on growth and yield

Within seed lots of birds foot trefoil, differences in seed size gave rise to differences in seed growth as larger seeds give larger seedlings (Mckensie and Tomes, 1980). There was however no consistent relationship between the seed size of different seed lots and the seedling produced, although lots containing a greater proportion of larger seeds had improved field emergence. Seed size, both volume and density has been recognized as a factor in plant growth and development for more than 50 years. Earlier experiment done by Kiesselbach and Helm (1957) resulted in a conclusion that seedling vigour was related to seed size. The more vigorous seedlings continued to produce more vigorous plant as the season progressed unless some environmental factor differentially affects the crop. Chastain *et al*. (1995) working on soft white winter wheat realized that, plants grown from larger seeds were taller, heavier and had more tillers than plant grown from smaller seeds.

Larger seeds appear to produce larger embryos as exhibited by the embryonic growth rate on a per embryo basis. However higher cotyledonary food reserves have been implicated in the superior performance of larger seed.

2.11 Seed production and development

Seed, a matured ovule, is the forerunner of the next generation in the life of a plant (FAO, 1981). The production of high – quality seed is of prime importance to propagators, whether they collect or produce the seeds themselves or obtain the seed from others (Hartmann *et al*., 1990). They observed that in nature, higher plants reproduce primarily by seeds and that the characteristic genetic variability among groups of seedlings is to allow continued adaptation of a particular species to possible changes in the environment.

According to Chopra (1982), seed production requirements may be decisive selection criteria in hybrid development for which varieties that do not pass Value for Cultivation and Use (VCU) are not normally allowed in the seed production system. Breeder seed is produced by a qualified plant breeder and monitored for quality during production by a joint team comprising crop breeder and other representative in seed production phase. The seed production phase starts with the breeder seed emanating from research stations and ends with the production of commercial seed either certified, or uncertified to be sold to farmers (Venkatesan, 1994). He also stated that an important issue relating to seed production is the one regarding seed demand as seed price is a function of the characteristics of the seed system (all the activities from selection and breeding to the marketing as well as the use of seed by farmers for growing crops).

In the generation system of multiplication, Agrawal and Dadlani (1984) made a statement that the availability of breeder seed of high genetic purity determines the success of entire seed production programme which is different from crop production. Seed production therefore is successful if it can make available, sufficient quantity of high quality seed at the required time, at a reasonable cost and at the place where it is needed. Small- scale farmers retain own groundnut seed after harvest, but large-scale producers buy new seed annually (Waele and Swanevelder, 2001). In the seed industry there are two basic ways open to ensure a supply of seed for the production of next generation of crop viz (ii) saving seed from their own crop (ii) buying in seed from elsewhere (Raymond and George, 1985).

Delouche (1982) stated that seed development used in formal seed system comprises a chain of processes stretching from manipulation of the germplasm at the research station through multiplication, processing and marketing, and eventually to seed purchase and use by farmers. Higher plants reproduce naturally by seed as the growing of seedlings is used in propagating more species and cultivars than any other means (Hartmann *et al.*, 1990). It was stated that varieties tested for seed production should be periodically tested for genetic purity to make sure that they are being maintained in their true form.

Seeds may be collected from seed production source and or hybrid seed production source. Private seed trade can be made an important channel to deliver new agricultural technology, especially new varieties to farmers in developing countries. However, strict enforcement of seed regulations and policies obstruct private companies from operating and delivering new technology (Vanketesan, 1994).

2.12 Seed germination

Germination according to Hartmann *et al.* (1990) is the activation of the metabolic machinery of the embryo leading to the emergence of a new seedling. Groundnuts undergo epigeal form of germination where the cotyledons come out of the soil (CTA, 1992). Mobilization of reserves during germination has been concerned with breakdown of storage carbohydrates and proteins in a variety of seeds (Matheson and Small, 1980). Factors stated as affecting germination include light, temperature, moisture salinity, allelopathy, germination injuries and seed viability (Mckensie and Tomes, 1980).

Injuries and disturbance to groundnut seeds are responsible for the loss of germinating capacity, and the ability of a seed to germinate at the desired time to ensure an adequate level of initial growth (vigour) confirms its physiological seed quality (Marrewijk and Louwaars, 1992). In groundnuts, poor germination is encountered if seeds are handled roughly during shelling, causing the embryo to fracture. Loss of seed germination potential in groundnut may also result from attack by *Aspegillus flavus*.

According to Dupriez and De leener (1988), the nutritional reserves stored in the cotyledons nourish the germ during germination. They further stated that in terms of germination small seeds are weaker and more unreliable than large seeds. Most farmers in developing countries do not conduct germination test with the belief that the pods protect the seed from loss of viability. Machine shelled seeds germinate less than hand shelled seed because of coat injury incident (Leopold and Kriedmann, 1975). Germination takes place 4-5 days after planting for shelled nuts but now low germination or failure of seeds to germinate can usually be ascribed to attack by soil-borne fungi (Tweneboah, 2000).

2.13 Seed quality and storage

Seed quality, as a method of measuring viability is very essential in successful seed propagation as a dead or dying seed is characterized by gradual decline in vigour and necrosis or injuries may appear in localized area of the integument (Hartmann *et al.*, 1990). Good quality is about high germination, reasonably pure, free from disease and insect attack.

Martin *et al***.** (1976) have stated that shelled nuts may become rancid after storage for two months or more when exposed to the air but rancidity is retarded when the nuts contain 5-8% moisture or less and the relative humidity of storage room is 60%. They suggested that seed life is doubled for each drop of 1% in moisture content and that optimum condition for seed storage in the groundnut pods is a good method although sometimes they are stored as a shelled or decorticated nut. The term given to conservation in the pod is "shell groundnut" and that conservation is best as much from the point of view of eating quality as from the point of view of seed germination quality (CTA, 1992).

Seeds may lose viability during storage and since the purpose of seed storage is to minimize loss of viability equilibrium, moisture content ought to be maintained (Agrawal and Dadlani, 1984). They stated that good quality seed can be obtained by controlling the seed production system. According to Nikolaena (1997), even with best storage facilities seeds deteriorate if management procedures and planning are not adequate and with that, stores should be well cleaned, pest controlled and optimum environment created. When seed extraction and drying have been completed, it is necessary to keep the seed under the best possible condition to ensure that the maximum potential germination and other seed quality factors are maintained (Raymond and George, 1985). Groundnut seeds stored in bins, silos and warehouses are liable to significant qualitative and quantitative losses (Waele and Swanevelder, 2001). Again, cold-rooms may be used by commercial seed producers requiring long-term storage. Storability of the nuts depends, mainly on the state of maturity, the completeness of the shell, methods of harvesting, threshing, drying and shelling (Tweneboah, 2000).

2.14 Effect of time of planting on seed quality

Nsowah and Tettey (1976) observed that planting in the minor season produces better quality seed than the major season. This was in support of an earlier report by Mercer-Quarshie (1977). It will appear that in the period of maturity during the hot dry weather, seeds produced were of lower laboratory and field emergence than those which matured after the hot dry weather (Green *et al.,* 1965). According to them, seeds which matured during the hot dry weather had wrinkled coats and green cotyledons and these two factors associated highly with low germinability. Abdalla and Hassan (1989) have stated an increase in germination when planting is done after Mid-June in Egypt and seed maturation occurs in October. The time of planting also influences the protein and oil contents of seeds. According to Sahoo *et al.* (1991), reduction in oil yield to lower seed yield associated with delayed planting in India. Mulalic (1969) on the other hand, observed that changes in the protein and oil levels in the seed, brought about by delayed planting and season of planting could be attributed to changing temperature and sunshine levels. According to him, high ambient temperature and prolonged sunshine affected seed filling stage and increased protein content.

2.15 Effect of storage on groundnut seed viability

Lantican (1984) observed that the viability of seed after storage and good emergence were determinants of yield. Nsowah (1977) had observed that drying procedures on harvested seeds influence germinability of seeds. He found drying temperature of 40˚-50˚C for 24hrs, to be adequate for the maintenance of groundnut plant viability and temperatures above 50˚C, for the same drying period lower the percent germination drastically. High drying temperatures cause fractures in the seed coat and the cotyledons which subsequently reduce the seed viability (Kowaleczuk, 1987).

Longer periods of storage reduce the viability of the seeds. Singh *et al.* (1988) observed a reduction in the percent germination of soya bean and groundnut seeds with the lapse of storage time. Soetopo *et al.* (1991) also found a linear negative relationship between the length of storage and percent germination in peas. Pendleton and Hartwig (1973) as well as Nautiyal and Zela (1991), noted that high storage temperatures and high seed moisture contents were the main factors responsible for the rapid fall in the viability of stored seeds. Boakye- Boateng and Humes (1975) observed that soyabean and other peas lose viability too rapidly to sustain commercial production in Southern Ghana unless the seeds are stored below 12% moisture in moisture-proof containers and kept under refrigeration.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location or Sites

The field experiment were conducted at the Plantation Crop Section of the Faculty of Agriculture, KNUST (6˚43'N, 1˚36'W) during the major and minor seasons in 2007. The soil was well drained sandy loam of Akuse series classified under Ochrosol. The major season study was conducted between April and August 2007, while that of the minor season was between October and December 2007. The experimental site is within the semi − deciduous zone with bimodal rainfall, from April to July, and then September to December.

3.2 Experimental Design and Treatments

The field experiment was laid in a Split-plot design with four replications. The four groundnut varieties were Adepa, Azivivi, Jenkaah and Nkosour were the main-plot factor and the seed size was the sub-plot factor. All the four groundnut varieties are improved cultivars (maturing in 110-120 days) recently released by the Crop Research Institute. The seed size used were three –small (seeds<5mm diameter or 37 g 100-seed weight), medium size (5.1-8 mm diameter or 53g 100-seed weight) and large size (8.1- 10mm diameter or 67g 100-seed weight). Each main plot was 6m × 6m, while the sub-plots measured 6m × 2m. There were four rows for each sub-plot and nine rows on a plot. The planting distance was 60cm between rows and 20cm within rows. Two seeds were sown per hill at a planting depth of 5cm.

3.3 Cultural and agronomic practices

3.3.1 Land preparation

The land was slashed, ploughed and harrowed on 5th March, 2007. Weeding was done by hand hoeing and/ or hand pulling when weeds were tender. Weeding began two weeks after planting until peg formation, to ensure that pegs are not destroyed. A basal application of single super-phosphate at a rate of 40kg/ha P_2O_5 was done due to the general low phosphorus content of the soil. Fertilization was done two weeks after planting using the side placement method. Cymethoate (E.C25) was applied at the rate 200ml/hat at 40 DAP using a knapsack sprayer at the rate of 200ml/ha at 40 DAP. Knapsack was used for the spraying.

3.4 Data collected

3.4.1 Soil characteristics

Soil samples were taken from several spots at 0-15cm and bulked together. The following parameters were analyzed.

3.4.1.1 Soil available phosphorus

Available soil phosphorus was determined colorimetrically using Pye Unican Spectrophotometer at 880 nm wavelength in absorbance after extraction with Bray P-1 extractant which consisted of 0.03*M* NH_4F and 0.025 *M* HCl and the ascorbic acid as the reducing agent.

3.4.1.2 Soil pH

The pH was determined in water at soil to solution ratio of 1: 2.5. Ten grams of soil was weighed into a 50 ml beaker and 25 ml distilled was added. The mixture was stirred and allowed to stand for 15 minutes. The pH was determined by inserting the electrode of 8120 Weicheim German pH meter into the suspension.

3.4.1.3 Soil total nitrogen

Soil total nitrogen was determined by the micro Kjeldahl procedure (Bremner and Mulvaney, 1982). The method involved the digestion of 1g soil sample in 5ml concentrated sulphuric acid and few drops of 30% hydrogen peroxide added to it with selenium as catalyst. By this method, organic nitrogen was then converted to ammonium sulphate and the resultant solution made alkaline by addition of 40% sodium hydroxide and ammonia distilled into 2% boric acid and titrated with standard hydrochloric acid.

3.4.2 Crop or plant parameters

3.4.2.1 Seedling emergence and seedling establishment

Within two weeks (14) after planting, the number of seedlings emerging from the subplot were counted and compared. The number of seedlings which could not survive within a month after planting were counted and then expressed in percentage.

Five plants of each plot were randomly selected and tagged for height measurements on each plot. Measurement was taken every fortnight with a measuring tape. Height was taken from the ground level to the topmost point, and the average for each plot was calculated.

The number of leaves that was fully opened from the tagged plants on each plot was counted every two weeks and the average for each plot was calculated.

The number of branches of the five tagged plants was counted and the average calculated for each plot. Counting started at 4 WAP for 3 periods in two weeks interval.

The diameters of the widest canopy spread of the tagged five plants were measured and the average calculated for each plot. Five consecutive plants from each plot were carefully uprooted, and washed in water. The number of nodules was counted at 35 DAP and the average number recorded for each plot. Five plants from each plot were randomly selected and cut at ground level from the two border rows of each plot. Total fresh shoot weight was taken using a Mettler 4000 balance in the Soil Science Laboratory at KNUST. The measurement was repeated at 4, 6, 8 and 10 WAP. The plant materials were oven dried at 80˚C for 72 hrs. The dried materials were weighed and the shoot dry weight recorded.

Five randomly selected plants from each plot were carefully uprooted and pods were pods were counted, separating them into filled and unfilled. The undamaged pods with seeds were counted as filled while pods very soft and with undeveloped seeds were considered as unfilled pods, at harvest.

Pods counted for each plot were dried in the sun for 14 days and seeds were extracted and counted. Average number of seeds per pod was calculated.

100 seeds randomly selected were weighed using Mettler 4000 scale to represent the 100-seed weight.

3.4.2.2 Crop growth rate (C)

The crop growth rate (C) was calculated using Radford (1967) formula

$$C = \frac{W_2 - W_1}{t_2 - t_1}$$

Where W_2 = total plant dry weight at time t_2 and

W_1 = total plant dry weight at time t_1

The functional approach is

$$Y = \frac{C}{[1+T\ Exp^{(-b(x-m)}]\ ^{1}/_{T}}$$

Where : Y= Yield

C= final above-ground dry matter

x= Time

T, b, m are constant

3.4.2.3 Shelling percentage

The weight of shelled seeds divided by total pod weight and expressed as a percentage.

$$\text{Shelling percentage} = \frac{\text{Weight of shelled seeds}}{\text{Total pod weight}} \times 100$$

3.4.2.4 Harvest index

Five plants for each treatment were cut at ground level and weighed to give the total weight. The pods were shelled, and grains were weighed. The weight of grain was expressed as a percentage of total weight of plant (Pods + Haulms) to give the harvest index.

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

The economic yield = weight of seeds.

The biological yield = total dry weight.

3.4.2.5 Final harvest and yield measurements

The overall pod yield per hectare of the cultivars and seed yield was calculated. Seeds were dried and weighed. The mean values for yield and 100-seed weight were calculated. The harvest area was 810m^2 and there were four rows for each sub-plot.

3.5 Data analyses

All data was analyzed with the analysis of variance (ANOVA) technique using Genstat statistical tool and the differences between the means were compared using the Least Significant Difference (LSD) method at 5%.

CHAPTER FOUR

4.0 RESULTS

4.1 Climatic and Soil analysis

Table 1: Rainfall, temperature and relative humidity data collected from meteorological station at KNUST within the two planting seasons– 2007/2008

MONTH	RAINFALL (mm)	TEMPS (°C)		R. HUMIDITY (%)	
		Min.	Max.	0900	1500
2007					
January	8.5	20.2	24.0	60	34
February	65.3	22.4	34.5	80	55
March	76.7	22.6	35.2	89	49
April	189.9	22.5	34.0	82	58
May	84.3	22.5	32.9	83	63
June	244.2	21.6	31.6	85	65
July	374.0	20.8	29.7	85	70
August	127.3	20.5	29.0	86	72
September	539.8	21.5	32.2	88	71
October	237.6	21.7	30.9	86	67
November	48.6	21.8	31.4	82	62
December	2.9	21.4	32.1	83	55
2008					
January	0.0	18.5	33.3	48	32
February	61.7	22.5	34.6	79	41

The meteorological substation at the Animal Science Department of KNUST was consulted for the needed climatic data for the area.

The total rainfall for the major season was 917.7mm and the season recorded total rainfall of 281.9mm.

The mean temperature for the two planting seasons was 21.4˚C. The mean maximum temperature for the major and minor seasons was 20.2˚C while the mean maximum temperature for the major and minor seasons was 22.6˚C. The relative humility recorded in the morning (0900 hours) was 98.9%. The major season recorded 42.1% relative humility. The minor season also recorded 25.1% relative humility.

Table 2: Initial characteristics of the soil at the study site

pH	5.56
%Organic carbon	1.32
% Organic matter	2.28
% Total N	0.10
Available P (mg kg^{-1})	16.20
Exchangeable cations ($cmolkg^{-1}$)	
Ca	4.00
K	0.35
Mg	1.40

The initial soil characteristics of the soil used for the study are presented in table 2.

4.1.1 Soil pH

The pH of the soil measured in water recorded a value of 5.56. Landon (1996) reported that soil with pH value > 8.5 is rated very high, 7.0 – 8.5 high, 5.5 – 7.0 medium and < 5.5 low. Based on these ratings, the pH of the soil could be rated as low. The low pH value obtained at the study site could be attributed to leaching of basic cations and also the amount of acidic cations present.

4.1.2 Organic carbon

The percent organic carbon content of the soil was 1.32 and that obtained for organic matter was 2.28. According to Landon (1996), soil containing organic carbon > 20% is rated as very high, 10 − 20% high, 4 – 10% medium, 2 − 4% low and < 2% very low. With reference to these ratings, the percent organic carbon could be described as low. This could be attributed to lack of addition of organic materials in the form of crop residues and farm yard manure.

4.1.3 Total N

The value obtained for total nitrogen (0.10%) was low. As reported to by Landon (1996), per cent total N content in soil > 1.0 is rated as very high, 0.5 – 1.0 high, 0.2 – 0.5 medium, 0.1 – 0.2 low and < 0.1 very low (Landon, 1996).

4.1.4 Available P

The available P content of the soil (16.20 mg kg^{-1}) could be rated as medium. Page *et al*. (1982) in referring to concentration of phosphorus soluble in dilute acid fluoride gave the following ratings: < 3 mg kg^{-1} very low, 3 – 7 mg kg^{-1} low, 7 – 20 mg kg^{-1} medium and > 20 mg kg^{-1} high.

4.1.5 Exchangeable bases

The soil recorded a medium amount of calcium (4.00 $cmolkg^{-1}$). Landon (1996) rated soils having Ca > 10 $cmolkg^{-1}$ as high and < 4 $cmolkg^{-1}$ as low. The Mg content of the soil was 1.40 $cmolkg^{-1}$. Magnesium content < 0.2 $cmolkg^{-1}$ is rated low, 0.2 − 0.5 $cmolkg^{-1}$ medium and > 0.5 $cmolkg^{-1}$ high (Landon, 1996). Based on these ratings the soil could be rated as having a high Mg content. The exchangeable K concentration of the soil sample recorded was 0.35 $cmolkg^{-1}$.

4.2 Seed Emergence and Seedling Establishment

Table 3: Effect of cultivar and seed size on seed emergence and seedling establishment of groundnuts in the major and minor seasons of 2007.

TREATMENT	EMERGENCE (%)			ESTABLISHMENT (%)		
	Major	Minor	Mean	Major	Minor	Mean
VARIETY						
Adepa	62.1	60.2	61.1	54.4	51.3	52.9
Azivivi	64.9	62.7	63.8	58.2	56.2	57.2
Jenkaah	70.4	67.8	69.1	66.3	61.4	63.8
Nkosour	63.2	61.4	62.3	63.5	60.8	62.1
LSD (5%)	9.5	8.7	9.1	16.4	12.1	14.2
SEED SIZE						
Small	65.8	64.8	65.3	57.2	56.5	56.8
Medium	60.3	63.1	61.7	60.4	59.1	59.7
Large	56.7	64.1	60.4	68.6	66.3	67.4
LSD (5%)	19.4	3.6	11.5	12.1	18.6	15.3
CV (%)	11.6	9.2	10.4	14.3	12.1	13.2

Seedling emergence and seedling establishment of plants from the various cultivars and seed sizes are presented in Table 3. All the varietal differences in the major season were not significant in the seedling emergence and seedling emergence. Seed sizes did not significantly affect seedling emergence and establishment. However, emergence was lowest with large seeds, while seedling establishment was also low in small seeds, numerically.

However, in the minor season, all varietals and seed size differences were significant at 5% for seedling emergence and establishment in the minor season of 2007.

4.3 Number of leaves

Table 4: Effect of cultivar and seed size on number of leaves of groundnuts in the major and minor seasons of 2007.

TREATMENT	MEAN No. OF LEAVES PER PLANT					
	MAJOR			MINOR		
	35DAP	49 DAP	63 DAP	35DAP	49 DAP	63 DAP
VARIETY						
Adepa	98.81	170.61	219.23	91.60	155.43	162.62
Azivivi	105.22	164.34	189.24	93.31	149.30	150.10
Jenkaah	101.34	169.43	221.80	94.13	154.41	158.63
Nkosour	109.23	172.04	207.13	101.20	157.01	162.20
LSD (5%)	14.41	28.90	32.97	16.39	30.29	33.85
SEED SIZE						
Small	104.72	164.43	205.50	93.71	149.41	155.81
Medium	103.22	176.62	203.21	95.60	161.42	158.93
Large	103.14	166.24	219.24	95.82	151.22	160.42
LSD (5%)	12.48	25.03	28.55	15..28	25.57	2.96
CV (%)	16.70	20.60	19.00	10.80	12.30	18.10

Results of the number of leaves at all sampling days are presented in Table 4. Seed size in the major season, did not affect leaf production. Varietal differences were also not significant at all sampling occasions, except at 63 DAP when Jenkaah produced significantly greater number of leaves per plant than Azivivi only.

Results of number of leaves in the minor season are presented in Table 4. At all the sampling, groundnut cultivar did not significantly affect number of leaves produced. Seed size did not significantly affect leaf production at 35 and 49 DAP. At 63 DAP, plants from small seeds produced significantly lower leaves than those from medium and large seeds.

4.4 Canopy spread

Table 5: Effect of cultivar and seed size on canopy spread of groundnuts in the major and minor seasons of 2007.

TREATMENT	**Mean canopy spread (cm/plant)**					
	MAJOR			**MINOR**		
	35 DAP	49 DAP	63 DAP	35 DAP	49 DAP	63 DAP
VARIETY						
Adepa	22.28	56.62	68.80	18.59	40.41	37.80
Azivivi	23.03	62.01	72.51	18.81	42.02	42.95
Jenkaah	22.58	61.00	71.99	18.58	39.10	39.10
Nkosour	25.53	62.13	70.98	21.53	44.21	43.74
LSD (5%)	1.15	5.92	4.51	3.56	6.11	5.81
SEED SIZE						
Small	22.55	58.04	70.73	18.67	39.32	40.73
Medium	22.89	61.04	70.91	18.86	35.10	39.25
Large	24.64	62.33	71.58	20.61	42.31	42.71
LSD (5%)	1.00	5.13	3.91	2.34	9.17	4.91
CV (%)	10.50	11.11	12.70	16.60	3.40	8.90

The results of the canopy spread of the various seed sizes and cultivars are presented in Table 5. Large seed size increases significantly (P≤0.05) with small and medium seed sizes at 35 DAP. The canopy spread also increased significantly (P≤0.05) with seed size particularly between Nkosour and other cultivars. At 49DAP, in the major season treatment differences between cultivars and seed size was significant. However large seed size had the widest spread than the other seed sizes. Adepa had the least canopy spread while Nkosour recorded the highest canopy spread. There were increases at 63 DAP but the differences were not significant.

Canopy spread of plants is presented in Table 5. At 35 DAP and 49 DAP, groundnut variety did not differ significantly in plant canopy spread in the minor season. At 63 DAP canopy spread of Nkosour was significantly higher than that of Adepa at 5% level of probability. Seed size did not affect plant canopy spread at 35, 49 and 63 DAP.

4.5 Number of Branches

Table 6: Effect of cultivar and seed size on number of branches of groundnuts in the major and minor seasons of 2007.

TREATMENT	MEAN No. OF BRANCHES PER PLANT					
	MAJOR			MINOR		
	35DAP	49 DAP	63 DAP	35DAP	49 DAP	63 DAP
VARIETY						
Adepa	17	17	19	13	13	15
Azivivi	17	17	19	13	13	15
Jenkaah	16	18	20	12	14	14
Nkosour	16	16	18	12	13	14
LSD (5%)	1.60	1.48	1.32	1.59	2.04	2.35
SEED SIZE						
Small	16	17	19	12	13	15
Medium	17	17	19	13	13	14
Large	17	17	19	13	13	15
LSD (5%)	0.68	1.28	1.14	1.45	1.17	0.73
CV (%)	11.60	10.50	8.40	15.90	12.10	6.90

Results of the number of branches at all the sampling days are presented in Table 6. In the major season, there was a significant difference ($P < 0.05$) between the number of branches produced by the medium and small seed sizes at 35 DAP where the effect of the medium seed plants produced greater number of branches. Difference between the effect of small and large seed plant was not significant. Cultivar differences were not significant. At both

49 and 63 DAP neither the cultivar nor the seed size had a significant effect on the number of branches per plant.

Groundnut variety and seed size did not significantly affect the number of branches on all sampling days in the minor season.

4.5 Shoot fresh Weight

Table 7: Effect of cultivar and seed size on shoot fresh weight of groundnuts in the major and minor seasons of 2007.

TREATMENT	MEAN No. OF SHOOT FRESH WEIGHT (g).					
	MAJOR			MINOR		
	35DAP	49 DAP	63 DAP	35DAP	49 DAP	63 DAP
VARIETY						
Adepa	26.04	371.00	401.01	25.53	248.40	284.01
Azivivi	21.59	288.02	293.03	20.76	155.51	209.22
Jenkaah	22.19	366.10	342.02	21.51	192.83	246.33
Nkosour	27.81	462.12	464.01	27.37	234.12	263.74
LSD (5%)	4.80	61.73	63.23	6.62	79.58	53.57
SEED SIZE						
Small	22.34	396.04	392.03	22.06	206.23	324.01
Medium	25.38	347.03	350.04	24.55	193.91	237.23
Large	25.50	373.02	384.02	24.76	234.11	266.30
LSD (5%)	4.16	53.42	54.71	4.19	43.25	32.86
CV (%)	23.70	20.00	20.30	17.40	23.90	16.30

The shoot weight over the sampling periods is presented in Table 7. Seed size did not significantly affect ($P > 0.05$) shoot fresh weight at all sampling occasions in the major season. Nkosour plants produced the highest shoot fresh weight at all sampling occasions (Table 7). At 35 DAP, Nkosour had significantly greater shoot fresh weight than Azivivi and Jenkaah varieties. Similarly, at 49 DAP, all varietal shoot weights were significantly lower than that of Nkosour and at 63 DAP, the treatment effect of Nkosour was higher than that of Azivivi and Jenkaah.

Shoot fresh weight results of plants from the various seed sizes and varieties are presented in Table 7. In the minor season, shoot fresh weight among varieties increased up to 63 DAP after which it declined. Cultivar differences at 35 DAP was not significant. At 49 and 63 DAP, the greatest effect was measured in the Adepa variety, but this was significantly higher than that of Azivivi only. All other varietal differences were not significant. Seed size effects were not significant at 35 and 49. However, at 63 DAP, shoot fresh weight of plants from small seeds was significantly higher than the medium and large seed sizes.

4.6 Shoot dry weight

Table 8: Effect of cultivar and seed size on shoot dry weight of groundnuts in the major and minor seasons of 2007.

TREATMENT	MEAN No. OF SHOOT DRY WEIGHT(g)					
	MAJOR			MINOR		
	35DAP	49 DAP	63 DAP	35DAP	49 DAP	63 DAP
VARIETY						
Adepa	7.42	65.34	85.30	6.15	44.22	50.00
Azivivi	8.21	57.22	66.21	5.37	36.71	33.01
Jenkaah	7.34	61.94	80.83	5.85	37.72	40.03
Nkosour	8.20	87.73	89.72	6.74	59.40	55.34
LSD (5%)	1.91	8.38	7.92	0.40	11.56	10.68
SEED SIZE						
Small	7.36	74.71	84.73	6.14	50.22	43.43
Medium	6.84	63.14	72.13	6.21	39.50	42.52
Large	7.37	66.24	75.20	5.73	42.91	47.83
LSD (5%)	2.41	7.26	7.52	0.48	5.58	7.97
CV (%)	15.70	14.80	22.60	9.30	17.30	15.00

The Table 8 indicates the shoot dry weight in the major season. At 35 DAP, the seed sizes as well as the cultivars did not produce significant differences in shoot dry weight at 5% probability level. However, cultivar and seed size effects on shoot dry weights differ significantly at 49 DAP at 5% level of probability. Among the varieties, Nkosour had the heighest shoot dry weight which was significantly higher than all the other varieties. The shoot dry weights of the rest of the varieties were not significantly different. Plants from the small seeds recorded the greatest shoot dry weight which was significantly higher than the other seed sizes. At 63 DAP, varietal differences of shoot dry weight was significant. Shoot dry weight of Nkosour was significantly higher than that of Jenkaah and Azivivi. Indeed, shoot dry weight of Azivivi, was not only the least, but also statistically lower in all other treatments effects. Shoot dry weight from the small seed treatment was significantly higher than from the medium and large seed treatments. However, treatment differences between medium and large seeds were not significant.

At 35 DAP in the minor seaon, there were significant differences ($P \leq 0.05$) among cultivars in shoot dry weight. The shoot dry weight per plant of Adepa was higher than that of Azivivi. At 49 DAP, Nkosour produced the greatest shoot weight which was significantly higher than all other varieties. The shoot dry weights of the other three varieties were statistically similar. At 63 DAP, differences between Adepa and Nkosour were not significant but the effect of Nkosour was higher than for both Jenkaah and Azivivi. Effect of Adepa was also greater than that of Azivivi. Seed size effects on shoot dry weight was significant at 49 DAP, where the effect of the small seed sizes was significantly higher than in all other treatments. Shoot dry weight of plants from large-sized seeds was greater than small seeds size. All other treatment effects were similar. On 63 DAP, seed size treatment differences was not significant at 5 % level of probability.

4.7 Number of Nodules

Table 9: Effect of cultivar and seed size on number of nodules of groundnuts in the major and minor seasons of 2007.

TREATMENT	MEAN No. OF NODULES					
	MAJOR			MINOR		
	35DAP	49 DAP	63 DAP	35DAP	49 DAP	63 DAP
VARIETY						
Adepa	96.50	210.23	212.00	92.83	172.91	161.23
Azivivi	110.33	316.22	173.14	105.31	237.81	133.84
Jenkaah	87.02	283.24	123.45	81.62	249.83	110.82
Nkosour	101.02	327.13	169.20	90.72	249.94	111.90
LSD (5%)	22.30	55.22	62.13	31.43	42.21	47.30
SEED SIZE						
Small	88.43	276.24	152.01	83.02	217.00	109.81
Medium	102.54	270.12	173.04	98.64	243.12	126.43
Large	101.53	306.23	182.51	96.24	222.83	145.63
LSD (5%)	19.31	47.83	53.73	15.74	39.51	28.55
CV (%)	27.60	23.40	44.20	21.20	11.60	23.30

The results on the number of nodules at all sampling days in the major season are presented in Table 9. There were significant differences among the cultivars. Azivivi produced greater number of nodules than Jenkaah only. At 49 DAP, Nkosour produced greater number of nodules and this was significantly higher than that of Adepa only. The Adepa variety produced the greatest number of nodules at 63 DAP which was significantly higher than the than the nodules produced by Nkosour. Other treatments effects were statistically similar. Nodulation was not significantly affected by seed size at all sampling periods (Table 9).

Results of number of nodules at all sampling days in the minor season are presented in Table 9. At 35 DAP, groundnut cultivar did not significantly affect number of nodules per plant. At 49 DAP, Adepa produced significantly lower nodule numbers than all others. At 63 DAP, nodules produced by Azivivi, Jenkaah and Nkosour were similar, but that produced by Adepa was greater than those of Jenkaah and Nkosour. Seed size did not affect nodule production, except at 63 DAP, when nodules produced by plants from the small seeds lower nodule numbers than that of the large seeds.

4.8 Yield and Yield Components

4.8.1 Number of Pods per plant and Pod yield

Table 10: Effect of cultivar and seed size on filled and unfilled number of pods of groundnuts in the major and minor seasons of 2007.

TREATMENT	Number of pods per plant and Pod yield per hectare (kg/ha).							
	Major				Minor			
	Filled	Unfilled	Total	Pod yield	Filled	Unfilled	Total	Pod yield
VARIETY								
Adepa	205	157	362	1611	51	27	79	1523
Azivivi	174	115	289	1697	42	24	66	1652
Jenkaah	147	165	312	1553	39	31	69	1653
Nkosour	174	155	329	1739	42	31	73	1548
LSD (5%)	55	71	126	54	13	8	21	90
SEED SIZE								
Small	169	141	310	1602	42	28	69	1427
Medium	192	141	333	1675	45	29	74	1622
Large	165	162	326	1701	43	31	74	1684
LSD (5%)	48	62	119	101	7	9	15	431
CV (%)	34	30	31	15	21	35	20	21

The results on filled and unfilled number of pods per plants in the major season from the various seed sizes and cultivars are presented in Table 10. There was significant difference between Adepa and Jenkaah in the number of filled pods at 5% level of probability. Azivivi, Nkosour and Jenkaah had similar number of filled pods. Filled pods were more than unfilled pods in the major season. Groundnut variety did not significantly affect number of unfilled pods. Seed size did not affect number of pods produced.

Results of pod yield per hectare for the various seed sizes and cultivars in the major season are presented in Table 10. Varietal differences in pod yield were significant at 5% level of probability. The greatest yield of 1739 kg/ha was produced by the Nkosour variety, and this significantly higher than pod yields of Adepa and Jenkaah. Pod yield of Azivivi was also significantly higher than that of Adepa and Jenkaah. Additionally, pod yield of Jenkaah was also significantly lower than that of Adepa. Seed size effects on pod yield was however, not significant. Seed size and groundnut cultivar did not significantly affect pod production in the minor season.

Results of pod yield per hectare of plants in the minor season are presented in Table 10. Pod yields of Azivivi and Jenkaah were not significant from one another, but either effect was significantly greater ($P<0.05$) than those of Adepa and Nkosour. Seed size did not significantly affect per hectare pod yield.

4.8.2 Fresh and Dry seed weight

Table 11: Effect of cultivar and seed size on seed fresh and dry weight per plant of groundnuts in the major and minor seasons of 2007

TREATMENT	SEED FRESH AND DRY WEIGHT (g)					
	Seed fresh weight			Seed dry weight		
	Major	**Minor**	**Mean**	**Major**	**Minor**	**Mean**
VARIETY						
Adepa	77.03	80.41	78.72	47.71	42.83	45.27
Azivivi	64.94	70.50	67.72	40.81	29.51	35.16
Jenkaah	53.74	59.83	56.78	33.54	28.22	30.88
Nkosour	68.10	71.82	69.98	42.03	37.14	39.58
LSD (5%)	19.92	28.30	24.10	13.85	18.92	16.38
SEED SIZE						
Small	64.52	67.34	65.93	39.34	32.81	37.07
Medium	64.34	69.43	67.13	40.92	33.23	37.07
Large	69.01	73.82	71.41	42.81	37.24	40.02
LSD (5%)	16.56	12.78	14.67	5.89	8.92	14.81
CV (%)	34.90	24.80	29.85	23.00	27.80	25.40

Seed fresh and dry weight results are presented in Table 11. Fresh seed weight of Adepa variety was significantly higher than that of Jenkaah only in the major season. The rest of the varieties had similar fresh weight. Seed size did not affect seed fresh weight. Seed dry weight from Adepa was also significantly higher ($P \leq 0.05$) than that of Jenkaah only, while all other treatment differences were not significant. Variety and seed size in the minor season did not significantly affect seed fresh and dry weights (Table 11).

4.8.3 100-seed weight, Harvest Index and Shelling Percentage

Table 12: Effect of cultivar and seed size on 100-seed weight, harvest index and shelling percentage of groundnuts in the major and minor seasons of 2007.

TREATMENT	100-Seed Weight(g)			Harvest Index			Shelling %		
	Major	Minor	Mean	Major	Minor	Mean	Major	Minor	Mean
VARIETY									
Adepa	44.75	48.92	46.8	0.82	0.42	0.62	89.9	72.3	81.1
Azivivi	47.58	51.25	49.41	0.99	0.59	0.79	76.1	67.6	71.8
Jenkaah	46.08	51.17	48.62	0.94	0.54	0.74	74.4	58.2	66.3
Nkosour	46.00	51.25	48.66	0.93	0.53	0.73	77.8	66.8	72.3
LSD (5%)	3.36	3.97	3.66	0.44	0.04	0.24	15.1	15.3	15.2
SEED SIZE									
Small	45.75	50.00	47.87	0.94	0.54	0.74	77.8	65.0	71.4
Medium	46.31	51.25	48.76	0.97	0.57	0.77	70.8	69.3	70.0
Large	46.25	50.69	48.87	0.96	0.56	0.78	83.3	68.4	75.8
LSD (5%)	2.91	3.20	3.05	0.47	0.07	0.27	17.6	4.8	11.2
CV (%)	8.80	4.90	6.89	14.6	14.2	14.4	14.8	18.6	16.7

The 100- seed weight of plants from the various seed sizes are presented in Table 12. Cultivar type and the seed size did not significantly affect the 100-seed weight in the major and minor seasons.

Results of the harvest index and shelling percentage are presented in Table 12. Among the cultivars, Azivivi had the greatest harvest index and this was significantly higher than the harvest index of other varieties. Jenkaah and Nkosour recorded similar harvest index, but was significantly higher than that of Adepa. Seed size did not affect harvest index. Shelling percentage was significantly affected ($P \leq 0.05$) by groundnut variety with Adepa producing the highest (89.93%), which was significantly higher than that of Jenkaah (74.49%) only.

All other treatment differences were statistically not different. Seed size did not significantly affect shelling percentage. Results of harvest index and shelling percentage of plants are presented in Table 12. Varietal type and seed size differences did not significantly affect harvest index and shelling percentage

4.8.4 Seed yield

Table 13: Effects of cultivar and seed size on seeds per plant, seed yield per hectare and seeds per pod of groundnuts in the major and minor seasons of 2007

	Major			Minor		
TREATMENT	Seeds/plant	Seeds Yield/ha	Seeds/Pod	Seeds/plant	Seeds Yield/ha	Seeds/Pod
VARIETY						
Adepa	68.64	6814	4.2	72.12	3047	2.4
Azivivi	57.74	6126	3.6	63.83	1652	1.5
Jenkaah	55.92	5498	3.5	63.24	2643	2.3
Nkosour	66.43	7147	4.1	71.31	3560	3.4
LSD (5%)	19.84	216	0.8	29.33	395	1.4
SEED SIZE						
Small	66.63	6088	3.8	67.82	1997	1.6
Medium	60.94	6968	4.1	67.14	3730	2.1
Large	63.91	6923	4.0	70.23	3873	2.3
LSD (5%)	17.18	37.3	0.37	14.40	240	1.6
CV (%)	38.40	4.2	0.28	16.50	21	15

Seeds per plant, seed yield per hectare and seeds per pod are presented in Table 13. The cultivars showed significant difference in both seasons. Seed size showed significant difference in the seed yield per hectare at 5% level of probability in both seasons. There was significant difference between Nkosour and Azivivi and the seed per pod in the minor season. The treatment difference between medium and large seed sizes was significant in the minor season but between the large and small, medium and small seed sizes the differences were significant at 55 level of probability in the seed yield per hectare.

Cultivar type and seed size did not significantly affect the number of seeds produced per plant in both seasons.

4.8.5 Crop growth rate

Table 14: Effect of cultivar and seed size on crop growth rate (C) of groundnuts in the major and minor seasons of 2007

TREATMENT	CROP GROWTH RATE(g/m^2/day)							
	Major				Minor			
	1-2	2-3	3-4	4-5	1-2	2-3	3-4	4-5
VARIETY								
Adepa	4.13	4.43	1.43	0.51	2.71	3.11	2.08	0.41
Azivivi	3.50	3.75	1.35	-1.49	2.24	3.74	2.52	0.08
Jenkaah	3.90	4.00	1.34	-0.88	2.28	3.02	2.00	0.17
Nkosour	4.68	3.85	1.85	1.10	3.78	4.23	3.13	0.29
LSD (5%)	2.11	2.47	0.87	1.54	1.52	1.56	2.41	0.34
SEED SIZE								
Small	4.81	4.92	1.71	0.01	2.46	2.94	1.93	-0.48
Medium	4.02	4.30	1.64	0.32	2.37	2.86	1.79	0.22
Large	4.91	5.14	1.65	0.15	2.63	3.01	2.24	0.25
LSD (5%)	0.95	2.24	1.24	0.33	0.36	1.25	0.84	0.41
CV (%)	9.20	8.60	12.11	5.80	7.30	8.70	3.60	14.20

Crop growth rate results of plants from the various seed sizes in the major season are presented in Table 14. At the final stage of measurement cultivar differences in the rate of growth were significant at 5% level of probability. Nkosour had the fastest growth of rate, and the slowest was found in Azivivi. Effect of Nkosour was significantly higher than for Azivivi and Jenkaah. Other treatment effects were not statistically different. Seed size differences did not affect crop growth rate. Crop growth rate measured on other intervals were not affected by crop variety or seed size.

Crop growth rate was significantly affected by groundnut variety during the first sampling (Table 14). In the minor season, growth rate of Nkosour was significantly higher than that of Azivivi only. Other sampling data show no difference among cultivars. Seed size did not significantly affect crop growth rate on all sampling occasions.

CHAPTER FIVE

5.0 DISCUSSIONS

5.1 Growth and development of groundnuts

5.1.1 Seedling emergence and seedling establishment

The small seed size emerged earlier (5 -7 DAP) than the medium and large seeds which emerged within 6-10 DAP. This observation agrees with the work done by Fehr and Probst (1971), Edwards and Hartwig (1971) who reported that planting media resistance is less on small seedling emergence than medium and large seedling emergence. Although the difference was not significant, seedling, emergence was highly active in the major season than the minor season. This might have been caused by the apparent moisture content of soil during the major season than the minor season (Waele and Swanevelder 2001). In addition to soil moisture, germination and seed emergence are known to be affected by soil temperature, depth of sowing, planting season (Waele and Swanevelder, 2001) although these were not verified in the present study.

Seedlings from larger seeds established well and had faster growth than the small and the medium especially in the minor season. The relatively high establishment rate in favour of large seed size is in agreement with work done by Swank *et al.* (1993) who reported that seedlings from larger and heavier seeds utilised cotyledonary reserve (UCR) at a faster rate to have greater rate of stem elongation and accumulation of root and shoot dry weight than the other seed sizes. Again, FAO (1981) reported that, large seed size has greater nutrient reserve and usually produce strong seedlings with satisfactory development of root and stems. The report by Delouche (1982) and Singh *et al.* (1988) that, small seeded varieties germinate and emerge better than all others regardless of cotyledonary energy storage, do not agree with this research finding.

Jenkaah appeared superior in terms of seedling emergence and establishment, to the other genotypes in both seasons. Adepa registered the lowest percent seedling emergence and establishment. This agrees with the work of Patel and Golayinka (1988) that, genotypes exhibited different growth and yield potential when there is better rainfall distribution. Jenkaah's high ranking in both seasons could mean it can reliably give maximum plant density which could be transplanted to greater seed yield. Small seed size emerged rapidly but did not translate in to height. Large seed size established well and also had the highest height. The trends in seedling emergence did not mostly follow the pattern of yield.

5.1.2 Plant height

Plants heights at 35 DAP and 49 DAP in the minor season, showed significant difference between large seed and other treatments. Chastein *et al.* (1995) had reported that soft white winter wheat plant grown from large and medium seeds were taller, heavier and had more tillers than plants from small seeds. Cotyledonary reserve in large seeds has influence in the initial growth of crops but has little importance in subsequent growth once leaves emerge, is similar to the recent observation. There was no significant difference between treatments but large seeded plants showed early growth. Jenkaah emerged rapidly but did not have the highest height. The greatest height of (31.87cm) was reported for Nkosour and this suggests the differential response of genotypes to environmental changes. Leopold and Kriedemann (1975) have reported that, there is differential growth in response to environmental changes as far as plants are concerned.

5.1.3 Number of leaves, nodules and branches

There was no significant difference among treatments in number of leaves and branches in the major season experiment. This agrees with Detroja *et al.* (1993) who found that the differences in seed size did not the influence number of leaves, nodules and branches. Nodulation did not vary among seed size treatment. Generally, seed size did not significantly affect number of nodules in the minor season. The nodules formed by the varieties are similar to those reported earlier by Yayock (1978) who reported that nodule count per plant should be between 194 -230.

5.1.4 Shoot fresh and dry weights

Large seeded plants had higher values of shoot and dry matter during the minor season. The shoot dry and fresh weight differences were not significant at the final measurement of growth as well plants from the various seed sizes. There was progressive increase in dry matter in the initial growth stage until 63 DAP when the drop in dry matter accumulation occurred. The results showed increase in shoot biomass with seed size confirms the work of Knauft *et al.* (1990) who have reported increased plant vigour and yield of groundnut with large seed.

5.1.5 Canopy spread

The number of leaves increasing with time and decreasing at the 63 DAP agrees with a report by a Squire (1993) that, in groundnuts the period between the appearance of successive leaves is a developmental duration that respond to temperature, and that, reproductive development is synchronized with leaf development, flowers, peg, and pods produce after a given number of leaves have been initiated. The large seed size had a relatively greater number of leaves reflecting in wide canopy spread in the major season than the minor although the differences were not significant.

5.1.6 Crop growth rate (C)

The results showed low rate of growth in the minor season as compared to the major season. In both seasons plants from large seed size had a relatively higher rate of growth than those from other sizes. Crop growth rate increased rapidly especially after fertilizer application. This confirms a report by Tweneboah (2000) that, groundnuts respond to phosphatic fertilizer since phosphorus affects rate of nitrogen fixation. The crop growth rate reached a peak and started declining at the (3- 4) interval. The decline in growth rate could mean that the crop started translocation of photosynthates from the vegetative part to the reproductive part, mutual shading and competition.

5.2 Yield and yield components of groundnuts

5.2.1 Number of pods

The overall pod yields (kg/ha) were relatively higher in plants from the large-sized seeds than the other seed sizes although the differences were not statistically significant. Many pegs formed pods with plants from the medium-sized seeds in the minor season despite the low growth rate. The large seed-sized plants ranked next. The finding confirms the work done by Youdewei (1995) who reported that application of fertilizer tends to encourage the seedlings from large seeds to grow vigorously than seedlings from small seeds. However, the final yield is independent of seed size. The high yield of pods in the major season as compared to the minor season agrees with the earlier report by Patel and Golayinka (1988) that, increased pod fill, pod formation and dry matter production is associated with rainfall (539.88 mm). According to Westoby *et al.,* the medium seed can be produced in greater numbers than large seeds from a given quantity of maternal resources available for investment in the offspring. The yield differences in pods could be due to genetic or environmental factors. Plants from the medium size seeds exercised superiority over the seed sizes on pod yield in the pot experiment. This could mean that when given the same leverage of resources each size has the capacity to convert energy and photosynthates into reproductive parts.

The significant difference between Adepa and Jenkaah shows how different crop genotypes respond to diverse environmental condition and adverse effect of groundnut pests. In the minor season, Adepa produced the greatest number of pods followed by Nkosour and the differences could presumably be due to the fact that some genotypes seemed better able to tolerate drought stress than others. Jenkaah and Azivivi tolerate adverse effects. Whenever moisture is lacking, peg development and pod filling are affected. Pendleton and Hartwig (1973) reported that pod filling in legumes is the most crucial process in the crops and can be hindered by lack of soil moisture.

5.2.2 Seed yield and 100- seed weight

The plants from large seed size produced the maximum seed yield per plant in both seasons. Large seed plants also the produced the heaviest seed in the minor season, although in the major season seed weights from large and medium – seed plants were similar. This shows a positive correlation between seed size and seed yield. Vindharmann *et al.* (1990) had also reported positive correlation between seed size and groundnut yield, however, Sahoo *et al*. (1988) and Sedano *et al*. (1988) found no correlation between seed size and yield. Pod filling and seed formation periods received comparatively much soil moisture resulting in rapid translocation of photosynthates to reproductive parts. Tweneboah (2000) has stated that groundnuts planted between April and May in the forest zone of Ghana gives high pods and seed yields. There was significant difference between small and large seed. The seed yield in large seed size was higher than small seed size. Plant growth affected seed yield.

5.2.3 Harvest index and shelling percentage

Generally, the plants from small-sized seeds had relatively lower value as regards the harvest index and shelling percentage. Detroja *et al.* (1993) had observed that differences in seed size did not significantly influence shelling percentage. The results showed that the minor season cultivation had higher economic and low biological yield than the major season cultivation.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The results presented showed that the plants from small seeds emerged rapidly as compared to the medium and large seed sizes. The plants from large seed size showed faster growth rate especially in the initial growth stage as expressed in the height, fresh weight and the crop growth rate. Seedling establishment was favoured in large seeds as many seedlings of small seeds displayed low seedling survival in the minor season. The faster growth rate in plants from large seeds did not however, translate into remarkable higher pod yield as compared to that of the plants from small seeds. Large seeds have been found to produce higher seed fresh and dry weight. Pod yield of plants from large seeds was higher than those from other seed sizes in both seasons. Results also showed that seed size becomes very important in the minor season when rainfall is low. The varietal differences in the study suggest that among the four genotypes, Jenkaah and Azivivi should be recommended for effective production in the minor season while Nkosour will be the ideal genotype for high yield in the major season.

6.2 RECOMMENDATION

The following recommendations can be made based on the results obtained.

1. Farmers must do proper seed selection, and large seeds must be used for high pod production, especially in minor season.

2. The national seed certification scheme must be strengthened to ensure high quality and preferably large seeds are available to farmers for cultivation.

3. The study must be repeated in other ecological zones to study the environmental impact on the present observations.

REFERENCES

Abbiw, D. K. (1990). Useful plants of Ghana. Longman. pp. 31 – 33.

Abdalla. S. T. and Hassan, M. Z. (1989). Optimum planting date for seed yield of irrigated soyabean in Egypt. Tropical Agriculture 66 (2): 145.

Agrawal, P. K. and Dadlani, M. (1984). Automatic seed analyzer use in seed science and technology. Seed Technology News 14:pp. 1-2

Boakye-Boateng, K. B. and Humes, D. J. (1975). Effect of storage conditions on germination of seed. Ghana Journal of Agriculture 8 (2): 109-114

Bremner, J.M. and Mulvaney,C.S. (1982). Total nitrogen. In: Page, A.L., Miller, R.H. and Keeney, D.R. (eds.). Methods of soil analysis. Part 2. Chemical and microbiological properties. American Society of Agronomy and Soil Science Society of America, Madison Wisconsin Inc. pp. 593-624.

Burris, J. S., Wahab, A. H. and Edje, O. T. (1971). Effect of seed size on seedling performance in soyabean. Crop Science 11:492-496.

Burton, J. W. (1987). Quantitative genetics: Results relevant to soyabean breeding. pp 211-247. In Witcox, J. R. (ed.) Soyabean improvement, production and use. 2nd edition. Agronomy Monograph. ASA CSSA and SSA, Madison W.I.

Chastein, T. F., Ward, K. J. and Wysocki, K.D. (1995). Stand establishment response of soft white wheat to seed bed residue and seed size. Crop science Journal 35 (1): 44-65.

Chopra, K. R. (1982). Seed production and distribution. Proceedings of the International Symposium on Sorghum. Nov 1988 ICRISAT, India.

CTA (1992). Tropical agriculture. Food legumes-storage in pods. Macmillan press. pp. 52-78.

Delouche, J.C. (1982). Accelerated ageing technique for predicting the relative storability of seed weights. Seed Science Technology 1: 427-452.

Detroja, C. R., Sadaria, S. G. Kampara. V.D. Kaneria, B.B. and Malavia. D. D. (1993). Influence of time of shelling and seed size on yield. Quality and nutrient uptake in groundnut (*Arachis hypogaea* L.). Indian Journal of Agronomy 40:169-171.

Duke, J. A (1981). Handbook of legumes of world economic importance. New York: Plenum Press.

Dupriez, L.A. and De leener, C.S. (1988). Land and life, Agriculture in African Rural Communities-Crop and soils. Macmillan Publishers, London pp. 151-154.

Edwards, C. J. and. Hartwig, E. E. (1971). Effect of seed size upon rate of germination in soyabean. Agronomy Journal 63:429-430.

Eicher, C. (1987). Food grain production in semi-arid Africa. Food security Research priorities in sub-saharan Africa pp. 3-8.

FAO. (1981). Cereal and grain-legume seed processing. Technical guidelines. 21:1-3.

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

Forbes, J.C. and Watson, R.D. (1992). Plants in agriculture. Cambridge University press; Cambridge, UK. pp.122.

Foster, S. A. (1986). Adaptive value of large seeds for tropical moist forest plants, a review and synthesis, Botanical Review 53: 260-299.

Gardner, F. P., Pearce, R. B. and Mitchell, R. L. (1985). Physiology of crop plants. lowa State Univ. Press Ames. pp. 327-330.

Gaur, Y. D. Sen, A. N. and Rao, N. S. (1974) Promiscuity in *rhizobium* association. Zbl Bakt about. 11Bd 129:168-372.

Gibbon, D. and Pain, A. (1985). Crops of the drier regions of the tropics. Longman group, UK limited. pp. 120-127.

Green, D. E., Pinnel, E. L. Covanah, L. E. and Williams, R. L. (1965). Effect of planting date and maturity date on groundnut seed quality. Agronomy Journal 57 (2): 165-167.

Gregory, W.C. and Gregory, M.P. (1986). Groundnuts; *Arachis hypogaea* in evolution of crop plants-ed Simmonds. Longman, London. pp. 155-154.

Hack, R.B. (1970). Emergence of crops in clay soils of the central Sudan rainlands in relation to soil water. Experimental 6:287-302.

Hartmann, H. T., Kester, D. E and Davies, F. T. (1990). Plant propagation principles and practices. 5th Edn. Publisher-Prentice Hall international Inc. pp. 55-73.

Hay R. J. and Walker. K. A. (1989). Introduction to physiology of crop yield. Longman Group. U. K pp. 18-29.

Hopper. W. W. Verholt, J.R.O. and Martin, J.R. (1979). Effect of cultivar temperature and seed size on the germination and emergence of soyabean. Annals of Botany (London) 44:301-308.

Johnson, D.R. and Leuders, V.D (1994). Effect of plant seed size on emergence and yield of soyabeans. Agron. J. 66:117-119.

Kidd, F. and West, C. (1991). Physiological predetermination; the influence of physiological conduction of seed on growth yield. II review of literature. An Applied Biol. 5:112-142.

Kiesselbach, T. A. and Helm, C.A. (1957) Relation of size of seed and sprout value to the yield of small grain crops. Neb. Agro Exp. Sta. R. S. Bull. 11.

Knauft, D. A., Gorbet, D. W. and Wood, H.C. (1990). The influence of seed size on agronomic performance of a small seeded Spanish peanut line. Proceedings of Crop and Soil Science of Florida 135-9.

Kochhar, S. L. (1986) Tropical crops- a textbook of economic botany. Macmillan Publishers Ltd pp. 157.

Kowalezuk, J. (1987). The effect of temperature of drying air on the course of drying and biological value of soyabean seeds. Zamedelesk Technika 31 (4): 325-232 in Field Crops Abstract 40:28.

Lamont, B. B. and Milberg, P. (1977). Seed Cotyledon size and nutrient content role in early performance of species on nutrient poor soils. New phytologists 137:665-672.

Landon, J.R. (1996). Booker tropical soil manual. A handbook for soil survey and agricultural land evaluation in the tropics and sub-tropics. Longman. 431pp.

Lantican, R.M. (1984). Soyabean Production in Asia. Paper prepared for World Soyabean Research iii, IOWA State University. Ames, LOWA 12-17 August, Abstract 131. Joln Willey and Sons Ltd.

Leopold, A. C. and Kriedmann, P. E. (1975). Plant growth and development. New York. McGraw-Hall.

Le Roy, A. R., Fehr, W. R. and Cianzio, S. R. (1991). Introgression of genes for small seed size from *Glyciene soja* INTO g. max Crop Science 31:693-697.

Litzenberger S.C. (1976). Guide for field crops in the tropics and tropics. Peace Corps Programme and Training Journal. Pp. 14-20.

Mansfield T. A and Davies, W. J. (1981) Stomata and stomatal mechanisms. In “The physiology and Biochemistry of brought Resista ACB pp. 315-347. Academic Press, London.

Marrewijk, W. K. and Louwaars, A.K. (1992). Seed supply system in developing countries. CTA, Netherlands pp.1.

Martin, P., Leonard, W. and Stamp, W. (1976). Principles of field crop production. Mcmillan Publishing Co, Inc. London. pp. 739-747

Mathesen, N. K. and Small, D. M. (1980). B-D Mannanases in germinating Lucerne (alfafa) seeds. Carbohydrate Research 82(2): 325-331.

Mckensie, B. D. and Tomes, D. T. (1980). Effects of seed size and germination, seedling vigour and cytoplasm leakage in wild oats and birdfoot trefoil. Canadian Journal of Botany 58:471-476.

Mercer-Quarshie, E. (1977). Effect of planting date on the yield of soyabean CRI Annual Report 1973-74.

Montieth, J.L. (1981). Does light limit crop production? In: Johnson, C.B. (ed.). Physiological process limiting plant productivity. Butterworth. pp. 23-38

Mulalic, N. (1969). Effects of some environmental factors on protein and oil content in soyabean grain on 'monroe' 'Hudson' varieties. Field Crop Abstract. Vol. 24:22.

Nambiar, P.T. and Rao, B.S. (1986). Effect of sowing depth in nodulation, N_2-fixing, root and hypocotyls growth and yield in groundnut. Experimental Agric. 23:283-291.

Nautiyal. P. C. and Zela, P. V. (1991). Effect of drying methods on seed viability and seedling vigour in Spanish groundnut. Seed Science and Technology (Switzerland) 198:451-459.

Nikolaena, M. G. (1997). Factors controlling the seed dormancy pattern in physiology and Biochemistry of Seed Dormancy and Germination, A. A. Khan, (Ed.). North Holl and Publishing Co. Amsterdam, pp. 385-411.

Nsowah, G. F. and Tetteh J. P. (1976). Preliminary Studies on the growth and yield of soyabean. Ghana Journal of Science 16(2):25-37.

Nsowah, G. F. (1977). Soybean germination and establishment. Tropical Grain legume Bulletin No. 8:51.

Page, A.L., Miller, R.H. and Keeney, D.R. (1982). Methods of soil analysis. Part 2. Chemical and microbiological properties. Second edition. American Society of Agronomy and Soil Science Society of America. Madison, Wisconsin USA. pp. 416 − 418.

Patel,M. S. and Golayinka, B. A. (1988). Effect of water stress on yield attributes and yields of groundnuts. Indian Journal of Agricultural Science 58:701.

Pendleton, J.W. and Hartwig, E. E. (1973). Soyabean improvement, production and uses. (Ed. Caldwell, B.E.) American Society of Agron. Inc. USA.

Purseglove, J.W. (1998) Tropical crops-Dicotyledon. Longman pp. 225-235.

Raymond, A. and George. T. (1985). Vegetable seed production. Longman group Ltd. London and N. York. pp. 4-30.

Sahoo, A. K., Kulkarni, G. N. and Vyakaranhal, B. S. (1988). Effect of seed size on yield and quality in bunch groundnut. Journal of Agricultural Science India 16:136-142.

Sahoo, N.C., Mahapatra, P.K. Dixit, R.C. and Utaray, S.K. (1991). Effect of sowing date on growth, yield and quality of soyabean and groundnut. Indian Journal of Agriculural Science 61(9):665-668.

Sedano, D., Barrales, M. Dominguez, S. and Sanchez, D.S.(1988). Groundnut (*Arachis hypogaea* L.) varieties of erect and trailing growing habit under rainfed conditions. Revista chapingo 12:34-39.

Singh, S. N., Srivastava, S. K. and Agrawal, S.C. (1988). Variability and germination of groundnut and soyabean seeds in relation to pretreatment with fungicidies, periods of storage and type of storage container. Tropical Agriculture (Trinidad and Tobago) 65(2):106-108.

Shitting, R. (2002). The tropical Agriculturist- Groundnut. CTA, Macmillan Ltd London pp. 1-4.

Smith, C. C. and Fretwell, S. D. (1974). The optimal balance between seed size and number of offspring. American Naturalist 108:499-504.

Soetopo, L., Koestrhati, P. and Soedarsono. H. (1991). Relationship between length of storage and seed viability in *Pisum sativum*. Abstract on Tropical Agriculture 16(4):96.

Squire, G.R. (1993). The physiology of tropical crop production. CAB press. pp. 19-21.

Stanton, M. (1985). Seed size and emergence time within a stand of a wild radish: The establishment of fitness hierarchy. Oecologia 67:524-531.

Stock, W. D., Pate, J. S. and Delf, J. (1980). Influence of seed size and quality of seedling development under nutrient conditions in five Australian and South Africa members of the Proteaceace, Journal of Ecology of seed size. Trend in Ecology and Evolution. 78:1005-1020.

Swank, J.C., Egli, D.B. and Pfeiffer, T.W. (1993). Seed growth characteristics of legumes differing in duration of seed fill. Crop Science 27:85-89.

Tindall, H.D. (1983). Vegetables in tropics. Macmillan Ltd., London pp 250-254.

Tinius, C.N., Burton, J.W. Carter, J. (1991). Recurrent selection for seed size on legume. Crop Science 31:1137-1141.

Tripp, R. (1995). Seed regulatory frameworks and resource poor farmers. Network Paper 51, Agric Admin ODI, London pp. 54.

Tweneboah, C. K (2000). Modern agriculture the tropics with special reference to Ghana Publisher-Cp – wood. pp. 189-190.

Venkatesen, V. (1994). Seed system in sub-Saharan Africa (World Bank Discussion paper). Africa technical Dept. series. World Bank, USA. pp. 2-76.

Vindhavarmann, P. Arjuna, A. Mahran, V. Ramlingam, S. and Sivaram, M.R. (1990). Effect of seed size on dry matter production and pod yield of groundnut (*Arachis hypogaea* L.) Madras Agric. Journal 77:260-261.

Waele, D. and Swanevelder, C.J. (2001). Crop production in tropical Africa. Goikink Graphic nv. Belgium. pp. 747-753.

Westoby, M. Jurndo E. and Leish M. R. (1996). Comparative evolutionary ecology of seed size Trends in Ecology and Evolution 7:368-372.

Westoby, M., Leishman, M. R. and Lord J. M. (1992). Comparative evolutionary ecology of size and seed dispersal. Philosophical transactions of the Royal Society B in press.

White J. W. and Gonzalez, A. (1990). Characterization of the negative association between seed yield and seed size among genotypes of common bean. Field crops Res. 23:1-17.

World Book of Encyclopedia (1990). A Scott Fetzer and Co Ltd. 15:213-215.

Yayock, J. Y. (1978). Comparative performance of three varieties of groundnut under different levels of N fertilizer at a site in Sudan Savanna. Ghana Journal of Agricultural Science 11:95-101.

Youdewei, A. (1995). Introduction to tropical agriculture. Longman Group limited, England. pp. 123-125.

DEDICATION

This thesis is dedicated to my parents, siblings, wife, children and friends.

DECLARATION

I hereby declare that this thesis has not been submitted for a degree and that it is entirely my own work and all help has been duly acknowledged.

…………………………	……………………………..
STEPHEN MARTINSON	DR. J. SARKODIE- ADDO
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CHAPTER SIX

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LIST OF ABBREVIATIONS

CGR	Crop growth rate
DAP	Days after planting
FAO	Food and Agriculture Organization
KNUST	Kwame Nkrumah University of Science and Technology
PAR	Photosynthetically active radiation
DAE	Days after emergence
WAP	Weeks after planting

ABSTRACT

Field experiments were conducted at the Plantation Crops section of the Faculty of Agriculture, KNUST, Kumasi (6˚ 43′N, 1˚ 36′W) during the major and minor seasons of 2007 to determine the influence of seed size on the growth and yield of four groundnut varieties. The varieties were Adepa, Azivivi, Jenkaah and Nkosour (all improved varieties maturing in 110 to 120 days. the seed sizes were small (<5mm diameter or 37g mean 100- seed weight), medium (5.1-8mm diameter or 53g mean 100-seed weight) and large (8.1-10mm diameter or 67g mean 100-seed weight) the The field experiments were laid out in a Split plot arranged in a randomized complete block design. The main plot factor was the groundnut varieties and the seed size as the sub plot factor. Under field in the major and minor seasons, plants from the large seeds had

Under field in the major and minor seasons, plants from the large seeds had higher establishment rate than the medium and small seed sizes of the same variety. The accumulation of dry matter during early seedling growth showed that the shoot fresh and dry weights of plants from large seeds were higher than small seeded plants in the major season. The difference between the number of pods and seeds produced by plants from the different seed sizes were higher in the minor season than in the major season. Plants from the large seeds had the least number of pods per plants in the major season but in the minor season plants from the large seed size showed superiority over the other seed sizes. The seed dry weight of plants from large seeds was almost 10% greater than plants from the medium seeds. Varietal differences were mostly significant in the minor

season where rainfall was low and productivity increased with seed size. In general at both seasons, plants from the large seed size were superior in terms of height, number of leaves, number of seeds, shoot dry weight and pod yield over the other seed sizes, especially during the minor season of cultivation.

Farmers are recommended to use the large seed size for cultivation especially during the minor season.