EFFECT OF SEED PRIMING ON RATE OF SEEDLING EMERGENCE, ESTABLISHMENT AND YIELD OF FOUR BAMBARA GROUNDNUT (*Vigna subterranea* L. Verdc.) LANDRACES

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BY

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DECLARATION

I hereby declare that this thesis is my own original work for the award of a Master's of Science (MSc) degree in Agronomy. No part of this thesis has been accepted for the award of a degree in this University. Furthermore, I declare that all sources cited are indicated and acknowledged by means of a list of references.

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ABSTRACT

The overall yield of any crop largely depends on high rate of seed emergence, adequate seedling establishment and growth and development. Bambara groundnut is a food security crop in the semi-arid savannas in Africa, providing human nutrition and health in subsistent households, yet, remains an underutilized legume species with little research intervention. This study assessed the effect of seed priming of four field-grown bambara groundnut landraces on seedling emergence, growth and grain yield at Wa and Kumasi in 2011 cropping season in the Guinea savannah and forest agro-ecological zones of Ghana respectively. There were marked site-specific significant differences ($p \leq 0.05$) among the traits assessed. Priming bambara groundnut seed in water for 24 h before sowing significantly enhanced final emergence, seedling establishment, growth and yield compared to the control (0hour prime). Furthermore, the primed Bambara groundnut genotypes flowered much earlier and produced greater dry matter, pod and grain yield at Wa than at Kumasi. The interactive effect of the landraces and the priming also revealed increased plant growth and grain yield in Kumasi than at Wa. This study offers useful information to improve bambara groundnut seed germination, plant stand and grain yield in the Guinea Savanna agro- ecological zone with more stressful environmental conditions. Finally, all the yield parameters were improved following seed priming, and 24 hours of soaking seeds in water is recommended since it appeared to be the best in most yield parameters.

DEDICATION

This thesis is dedicated to the Almighty God for His abundant graces bestowed on me to come this far. To Mrs Nungdaamah Vuozie and Mrs Elekumah Bapiele Vuozie my biological and foster mothers, respectively for nurturing and educating me. Mrs Ernestina Naah Vuozie my wife for her love and encouragement to pursue a Master's degree, and my siblings Joseph Allan Vuozie, Solomon Dakura Suglo, Benjamin Dakura and Philip Ninyeni Vuozie for their sacrifices during the course of this study.

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CHAPTER ONE

1.0 INTRODUCTION

Bambara groundnut (*Vigna subterranea* L.Verdc) is an indigenous African legume widely cultivated in sub-Saharan Africa (Baudoin and Mergeai, 2001). Its origin in Africa is obscure however; earlier studies by Doku and Karikari (1971) showed that the species *Vigna subterranea* var. *subterranean* is a progenitor of its wild relative *Vigna subterranea* var. *spontanea.* Hepper (1963) reported that the wild bambara groundnut species originated from north Yola in northeast Nigeria and Garoua in northern Cameroon. Similarly, the crop has been reported to grow in many parts of Africa including Ethiopia, Niger and Mali (Lewicki, 1974). It is ranked the third most important grain legume in semi-arid Africa after groundnut and cowpea (Rachie and Silvester, 1977).

It is adapted to drier areas and produces grain where other legumes cannot thrive. It fits well into traditional cropping systems in Africa, and is usually intercropped with sorghum, maize and millet (Linnemann and Azam-Ali, 1993; Sesay *et al.*, 1999). Grain yield in Africa ranges from 650-850kg/ha with huge differences between agro-ecologies and landraces (Linnemann, 1994).

It is an important source of rich and cheap protein in the diets of many rural households in Africa. In Ghana, for example, it is an important food security crop in the savanna and transitional agro-ecological zones (Berchie *et al*., 2011). In Northern Ghana, Anchirinah *et al.* (2001) and Haleegoah *et al.* (2005) reported on its role in the celebration of traditional funeral rites as well as being a major gift exchanged between communities.

Its grain contains about 33% and 66% total essential and non-essential amino acid, respectively (Amarteifio *et al*., 2006). The haulms are palatable just as the leaves are rich in N and P, and therefore, an excellent source of animal feed (Rassel, 1960; Doku and Karikari, 1971). Brink and Belay (2006) reported that an infusion from the leave can treat abscesses whilst the roots are used as aphrodisiac.

In rotations with cereals, bambara groundnut can potentially improve soil N fertility (Mukurumbira, 1985) and subsequently, enhance crop yield through symbiotic N_2 fixation with compatible native micro-symbiont (Dadson *et al.,* 1988). Despite its important biological traits and the unique role it plays in the diets of rural households, seed germination and emergence, and nodule formation of the species are often slow and inconsistent with different soil moisture regimes, soil types and genotypes.

Linnemann and Azam-Ali (1993) reported that the low grain yield of bambara groundnut is associated with poor seed viability, crop establishment and plant density. Similarly, Berchie *et al*. (2010) showed that bambara groundnut landraces differ markedly in their ability to germinate. Within the same landraces, for example, seedling emergence varied from 7 to 21 days after sowing (DAS) (Sesay and Yarmah, 1996; Berchie *et al.,* 2010). Bambara groundnut yield is therefore, regulated by seed viability, crop establishment and plant density. Incidentally, some genotypes with hard seed coat tend to inhibit moisture permeability and thus, affect germination rate. Zulu (1989) earlier attributed poor bambara groundnut seed germination to restrictive uptake of water due to hard seed coat. Subsequently, crop establishment, nodulation, and days to flowering and physiological maturity, grain and dry matter yields are affected.

Seed priming (i.e. soaking seed overnight) in water and drying prior to sowing can markedly improve seedling emergence, plant stand and establishment, seedling vigor and final yield (Harris *et al.,* 1999; Rashid *et al.,* 2002). Furthermore, Rajpar *et al.*

(2006) found that relative to the control (i.e. without soaking) seedlings emerged much faster and reached maturity earlier when soaked. They also reported that priming seed with fresh water enhances seed germination than 0.2 and 0.4 % gypsum treatment.

Other studies by Massawe *et al*. (2005), showed that soaking bambara groundnut seed in water for 24 to 72 h promoted initial germination by two to three days depending on the landrace. It has also been postulated that advance metabolic processes resulting from seed priming induces early seedling emergence and physiological maturity.

Bambara groundnut though an important food security crop in the semi-arid region in Africa, its potential has not been fully exploited relative to cowpea, soybean and peanut (Linnemann, 1994; Drabo *et al*., 1997). Unfortunately, it remains an underutilized crop because of the little research interest and intervention it has received. This study was undertaken to determine the impact of seed priming on the growth and yield of bambara groundnut landraces in two agro-ecological zones in Ghana.

The specific objectives of this study were to determine:

1. the effect of priming on seed emergence, seedling establishment, and growth of bambara groundnut landraces.
2. the effect of seed priming on the yield and its components of bambara groundnut landraces.
3. the optimum priming time for bambara groundnut landraces.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Botany

Bambara groundnut (*Vigna subterranea* L Verde) belongs to the *leguminosaea* family. It is a grain legume indigenous to Africa, and is mostly grown by subsistent farmers. It grows in the wild in central Nigeria spreading to east and southern Sudan, but is cultivated throughout tropical Africa (Brink and Belay, 2006). All cultivated landraces evolved directly from their wild relatives. Doku and Karikari (1971) for example, reported that the cultivated bambara groundnut species originated from its wild relative (*Vigna subterranean* var. *spontanea*). Hepper (1963) supported the argument that the wild bambara groundnut species originated from north-east Nigeria and northern Cameroon. Other studies showed that this legume species (i.e. wild species) is widespread in Ethiopia, Niger, and Mali (Lewicki, 1974). The crop has a well developed tap root with many lateral stems growing up to 20 cm which support the growth of trifoliate leaves. Its petioles grow up to 15 cm in height, grooved, with green or purple color at the base. The flowers are typically *papilionaceous*, borne on long racemes with hairy peduncles arising from nodes on the stems. The branching ecotypes are usually self-pollinated whilst the spreading ones are cross-pollinated. The nuts which vary from 1 to 5 cm in diameter, are usually round, slightly oval-shaped and wrinkled with one or two seeds borne below ground. It takes 7 to 21 days to germinate and flowering starts from 30 to 35 DAS and may be determinate or indeterminate (Swannevelder, 1998).

2.2 Utilization of Bambara groundnut

Bambara groundnut serves as an important source of rich but cheap protein in the diets of many poor rural households in sub-Saharan Africa who can hardly afford expensive animal protein. In addition to its dietary value, the ease of storage and transportation makes it an important source of calories in rural communities. In Ghana for instance, Bambara groundnut is an important food security crop in the savannas and transitional agro ecological zones (Berchie *et al*., 2011). Also, the crop plays an important role in traditional ceremonies such as funeral rites and constitutes valuable gifts in most communities in Ghana, especially in the northern sector of the country (Anchirinah *et al*., 2001; Haleegoah *et al*., 2005).

Its grain contains 33 and 66% essential and non-essential amino acid, respectively (Minka and Bruneteau, 2000; Amarteifio *et al*., 2006). Lysine being the major essential amino acid represents about 10.3% of the total essential amino acid profile in this legume species. Bambara groundnut is a good source of leucine and contains a reasonable amount of phenylalanine, histidine and valine. Because of the high level of protein and carbohydrates in bambara groundnut, it constitutes a complete balanced diet in many households in Africa (Rowland, 1993; Nnanyelugo *et al*., 1985; Akubuo and Uguru, 1999). Elsewhere in Africa, the grain is roasted, pulverized and used as an ingredient in preparing soup just as bread is made from its flour in Zambia (Linnemann, 1990). Again, the grain of bambara groundnut can be processed and used to prepare local recipes such as ‘akara’ and ‘moin-moin’ in Nigeria (Obizoba, 1983). The flavour of bamara groundnut milk has been reported to compete favourably with those of cowpea, pigeon pea and soybean (Brough *et al*., 1993). The medicinal value of the crop has also been reported by Brink and Belay (2006). Preparations from the leaves are known to treat abscesses, while the roots are thought to contain aphrodisiac properties.

In the livestock industry, bambara groundnut leaves and husks are an excellent animal feed while the grain constitutes an important feed ingredient in the poultry sector (Oluyemi *et al.,* 1976). The haulms are palatable (Doku and Karikari, 1971) and the leaves are a rich source of N and P, and therefore, suitable as animal feed (Rassel, 1960). The potential of bambara groundnut to improve soil N fertility via symbiotic N_2 fixation has been documented (Mukurumbira, 1985; Dakora, 1985).

In West Africa, the current demand for Bambara groundnut far exceeds the supply as an invaluable part of human diet (Coudert, 1984).

2.3 Constrains in Bambara groundnut production

Optimizing the benefits of bambara groundnut will require overcoming those factors that limit production. For example, low soil fertility, unimproved planting material and poor agronomic practices generally limit crop yield on the Africa continent. Additionally, several biotic, abiotic and socio-economic factors can affect bambara groundnut production (Berchie *et al*., 2011).

In addition to overcoming production constrains to maximizing grain yield, the difficulty in cooking bambara groundnut remains a challenge (Berchie *et al*., 2010). Some studies have shown that reducing the cooking time is imperative to saving farmers, processors and consumers' time, money and energy so as to enhance its production and consumption. Although bambara groundnut is thought to be drought tolerant, its initial establishment requires some amount of moisture for proper development and increased grain yield.

The cultivation of this legume species is labour intensive more so at the time of final harvest. This legume species is mostly grown in the open drier savannas. However, in the transitional agro-ecological zone where the crop is grown, greater percentage of the labour force is sourced from migrant worker (Berchie *et al.,* 2011).

Because there are no improved bambara groundnut genotypes, farmers tend to rely on their own planting materials; a great disincentive to increased grain yield. So far, no improved bambara groundnut genotype has been released by the scientific community, underscoring its state as a neglected legume species. Some findings by Bilington (1970) and Begerman (1986b and 1988a) suggest that bambara groundnut is resistant to insect pests and diseases. However, in the humid environments, *Cercospora leaf spot, Fusarium wilt* and *Sclerotium rot* have been reported (Billington, 1970; Begemann, 1986b, 1988a).

2.4 Growing Environmental Requirements

Bambara groundnut is known to adapt to stressful environmental conditions (Heller *et al.*, 1997; Alakali and Salimelun, 2007). In drier parts of sub-Saharan Africa, it is mainly grown by female farmers on a small scale either in pure cultures or intercropped without improved cultural practices (Ntundu *et al.*, 2004). It thrives best in deep, well-drained and friable soils (Johnson, 1968) with pH of 5.0 to 6.5, and annual rainfall of 600 to 1200 mm. Because of its tolerance to several agro-ecologies, it can produce fair quantities of grain where other legumes may fail (Wassermann *et al.*, 1983).

Babiker (1989) for example, showed that under moisture stress, it produces greater grain yield than groundnut. Furthermore, Sreeramulu (1983) and Zulu (1989) demonstrated the effect of temperature, seed size and age as well as genotypic differences on bambara groundnut seed emergence. In general, the performance of any crop in any given environment is determined by nutrient availability.

2.5 Priming, emergence, and establishment

Bambara groundnut seed germination is slow and sporadic on the field and could take up to 21days (Sesay and Yarmah, 1996). Germination is usually hypogeal, as the cotyledon remains on the ground. Zulu (1989) reported that seed germination in bambara groundnut could be more sensitive to moisture stress than groundnut.

Berchie *et al.* (2010) also found that seedling emergence in bambara groundnut was inconsistent among the same landraces; and could range from 7 to 21 DAS. Optimizing bambara groundnut establishment in the field therefore requires that, a good percent of seed sown should germinate. However, hard seed coats of some genotypes inhibit water inhibition, delay seedling emergence and plant establishment (Zulu, 1989). Seed priming can increase the germination rate of bambara groundnut (Rha and Jamil, 2007). Sivritepe and Dourado (1995) proposed osmo-conditioning as an easy physiological technique of seed priming to enhance and synchronize germination rate in bambara groundnut. Berchie *et al.* (2010) reported that soaking bambara groundnut in water for 24 hrs before sowing significantly improved seedling emergence and establishment. Massawe (1997) showed that soaking bambara groundnut in water for 24 to 72 hrs promoted seed germination. Other studies showed that good seed germination and emergence resulted in higher grain yield of bambara groundnut (Linnemann and Azam-Ali, 1993). Rajpar and Wright (2000) also found that early seedling emergence and physiological maturity because of priming was possibly due to advance metabolic activities. Also, soaking bambara groundnut seed overnight in water and drying prior to sowing markedly improve plant stand, seedling establishment and vigour, and final yield (Harris *et al.*, 1999; Rashid *et al.,* 2002). Rajpar *et al.* (2006) further showed that seed priming in fresh water significantly reduced days to seedling emergence and plant maturity relative to no priming and 0.2 and 0.4 % gypsum treatments.

2.6 Nodulation in Bambara groundnut

Biological nitrogen fixation (BNF) is an important, cheap, sustainable and environmentally friendly source of nitrogen for natural and agro ecological systems functioning (Dakora and Keya, 1997). Several studies have reported on the significant N input from BNF and impact on crop yield in Africa (Dakora and Keya, 1997). For any symbiosis to occur, the host plant must recognize its compatible native rhizobial species. The recognition and colonization of rhizobia on legume roots result in the formation of nodules that are the sites of N_2 fixation. Although BNF is a significant source of N input into agricultural systems, moisture stress has been reported to depress nodulation and symbiotic processes (Martins *et al.,* 1999; Egharevba and Law-Ogbomo, 2007).

In addition to the effect of moisture stress on the legume-rhizobia symbiosis, high soil nitrate (Streeter, 1988), low soil P (Vance, 2000), the presence of compatible and effective rhizobial species (Abaido *et al.* 2009) and insect pests attack can decrease the actual amount of N-fixed. Similarly, the type of legume species and even differences in genotypes can affect the symbiotic process. Extreme temperatures have also been reported to affect nodulation and symbiotic functioning in legume (Bjorkman *et al.*, 1980). It has been shown that high temperature above 47°C reduces rhizobial population and survival (Bjorkman *et al.,* 1980; Hungria *et al*., 1997). Similarly, low temperature has been reported to depress rhizobial competitiveness for nodulation (Hardarson and Jones, 1979). In global agricultural production, N and P deficiency can limit crop yields. For example, N is a constituent of macromolecules such as DNA, RNA, enzymes and chlorophyll, whilst P is involved in ATP synthesis that regulates many biochemical processes in plants.

Soils in sub-saharan Africa are generally low or poor in nutrient content. Chemical fertilizers that could increase soil N fertility are expensive and sometimes unavailable to many resource-poor households. A sustainable approach is to include symbiotic legumes into traditional cropping systems to exploit their N_2 fixing potential. Earlier studies in the African continent have amply demonstrated N contribution from symbiotic legume (Dakora and Keya, 1997). Recent studies support the argument that grain legumes such as cowpea can contribute huge amount of N to traditional cropping systems (Belane and Dakora 2010).

2.7 Cultivation and yield of Bambara groundnut

Bambara groundnut can potentially contribute to the food security needs of many rural households in Africa even though it is grown under traditional low input cropping systems (Rachie and Silvester, 1977; Anonymous, 2004) However it is a neglected crop. That notwithstanding, some landraces have been selected for earliness in maturity, larger seed size and other useful biological traits (Doku and Karikari 1971). Because bambara groundnut has not received enough research intervention, grain yield at farm level remains low. Some studies suggest that poor seed viability resulting in low germination rate and crop establishment (Linnemann and Azam-Ali, 1993) contributes to low yield. There is some evidence to suggest that bambara groundnut can increase yield up to 3 t ha^{-1} in glass house and field conditions with good management (Collinson *et al.*, 2000). Due to the high heterogeneity associated with different bambara groundnut landraces, they tend to differ in days to emergence, and response to temperature and moisture regimes (Zulu, 1989; Kocabas *et al*, 1999). Bambara groundnuts tend to exhibit unique morphological features, such as seed size, shape and colour, which can be used to identify them. Interestingly, colour and the centre of production or collection have been used as their identities. Such informal methods of identifying them can result in double naming of a landrace because of introduction of seed from other places or movement of people across the African continent (Massawe, 1997).

Under adverse environmental conditions, bambara groundnut has the potential to produce a fair quantity of grain. Although advanced metabolic processes have been used to explain grain yield under stressful environmental settings, high root / shoot biomass ratio and reduced leaf area are thought to contribute to reduced transpiration loss by this legume specie (Collinson *et al.*, 1996).

Bambara groundnut is the second most important indigenous grain legume after cowpea in Africa (Doku and Karikari, 1971). Initially, the production and utilization of this legume species was much greater than cowpea (Doku, 1996). However, with breeding for high grain yield, improved insect pests' tolerance and earliness to maturity in cowpea, the production of bambara groundnut tended to declined (Doku, 1996). It is estimated that world bambara groundnut production stands at 330,000 mt with West Africa contributing between 45 to 50% (Coudert, 1984). In the African continent, grain yield ranges from 650 to 850 kg/ha (Linnermann, 1994).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Site Description

Field experiments were conducted at the Faculty of Agriculture research field, Kwame Nkrumah University of Science and Technology-Kumasi (KNUST) and at Siiriyiri demonstration site at Wa in the Upper West Region of Ghana in the 2011 cropping season.

The KNUST site (06^{o} 39$^{'}$; 01^{o}.39$^{'}$) is in the semi-deciduous forest zone of Ghana, and is characterized by a bimodal rainfall pattern. The major rainy season starts from March to July whilst the minor season starts from late August to November. The mean annual rainfall is about 1500 mm. The soils are sandy loams and classified as Ferric Acrisol (FAO, 1993). The second experiment was conducted at Wa (9^{o}35$^{'}$N; 2^{o}50$^{'}$W) in the Upper West region of Ghana. The vegetation is a Guinea savannah type with altitude varying from 200 m to 350 m. It has a mono-modal rainfall regime and the rainy season is from April to September, with an annual mean rainfall of about 1150 mm. According to FAO (2001), the soils are classified as Ferric Luvisol.

3.2 Experimental Designs and Treatments

The experimental design used at each location was a 4 X 4 factorial, with treatments arranged in a Randomized Complete Block Design (RCBD).The factors were (A) landraces (Burkina, Mottle cream, Zebra colour and Black eye) and (B) priming treatments (i.e. soaking seeds in water for 0, 6, 12, and 24 hours before planting). Each treatment was replicated three (3) times at each location.

3.3 Planting and cultural practices

The seeds of the landraces were obtained from the market legume sellers in Wa. The fields were ploughed, harrowed and divided into three blocks each with 16 plots per block, given 48 plots of each of the location with 3mx3m plot dimensions. The landraces (Burkina, Mottle cream, Zebra colour and Black eye) were primed (i.e. soaking their seeds in water for 0, 6, 12, and 24 hours before planting). Each treatment was replicated three (3) times at each location. Two seeds were sown per hill on the ridges. The inter and intra-row spacing were 50cm x 20cm. Seeds were sown at approximately 5 cm depth using a measured dibber to minimize errors resulting from the effect of sowing depth on seedling emergence and establishment. After seedlings emergence, they were thinned to one plant per hill at 20 days after sowing (DAS) to give 10 plants per m^2 or 90 plants per plot of ($9m^2$). Two weeding were done manually with hand hoes.

3.4 Data collection

Data collected were days to 50% seedling emergence, percentage establishment, days to 50% flowering, canopy spread, plant height, number of leaves, fresh and dry nodule weight, plant stand at harvest, pod and seed yield, shoot biomass at harvest, 100 seed weight. Pod and grain harvest indexes were determined by dividing the pod and grain yields by the total biomass yields excluding the roots.

3.4.1 Days to 50% emergence and flowering

This was done by determining the number of days that 50% of seedlings expected to emerge on a plot had emerged and is calculated as one over the number of days to 50% emergence. Seedlings were considered to have emerged when the first true leaves have been broken from the soil and are visible. Day to 50% flowering was also determined by counting the number of days that 50% of the plants on a plot showed at least one opened flower.

3.4.2 Plant height, Number of leaves and Canopy spread

Plant height was taken by measuring the height of five randomly sampled plants from the base to the highest point with a meter rule and the mean height calculated. The trifoliate leaves were counted as one leaf; and the leaves of the five sampled plants were counted and the mean determined. At 60 DAS, the canopy spread was measured by putting four sticks at the four crossed sides of each of the plants to be measured. Tape measure was then used to measure across, and averaged as canopy spread.

3.4.3 Nodule Dry weight or biomass at flowering

Fresh nodules were collected from five plants at flowering were oven dried at 80 ^{o}C for 48 hours and the dry weight taken as dry nodule weight. Also, shoots of 10 plants at flowering from one metre square area were collected, weighed fresh and oven-dried at 80^{0}C for 48 hour. The oven- dried shoots were then recorded as above ground dry weight at flowering.

3.4.4 Yield and Yield components

Total pods from ten plants in a meter square area were harvested, weighed fresh and dried, the dry pods and grain (seed) separated, weighed and recorded as pod and grain yield. Hundred seeds from each of the treatments were randomly counted and weighed; this represented the hundred seed weight at harvest and the harvest index was also calculated as the ratio of grain yield to total aboveground dry matter at maturity. The ratio of the economic yield (Grains) to the biological yield (biomass) was calculated to give the harvest index (HI= Economic yield/Biological yield).

3.9 Data analysis

Data collected were subjected to analysis of variance (ANOVA) using GENSTAT 11th edition (Gen Stat, 2009). Prior to analysis, the data in percentages were transformed using ARCSINE transformation. Fischer's least significant difference (LSD) was used to separate means.

CHAPTER FOUR

4.0 RESULTS

4.1: Days to 50% emergence and flowering and Rate of seedling emergence

There was no significant difference (P>0.05) in rate of emergence, days to 5o% emergence and days to 50% flowering among all the bambara groundnut landraces (Table 4.1). However, priming did affect both rate of seedling emergence and days to 50% emergence. Rate of seedling emergence was lowest in the control treatment and this was significantly low (p<0.05) than the effect of 12 and 24 hours priming treatments. Priming at 6, 12 and 24hours resulted in similar rate of seedling emergence.

Days to 50% emergence were greatest in the control treatment (Table 4.1), but this effect was significantly higher than only the 12 hours priming treatment. All other treatment differences were not significant.

Table 4. 1: Effect of landraces and seed priming on emergence, days to 50% emergence and days to 50% flowering of four Bambara groundnut landraces in Kumasi.

Treatment	**Rate of seedling emergence**	**Days to 50% emergence**	**Days to 50 % flowering**
<u>Landrace (L)</u>			
Burkina	0.149	6.8	48.7
Mottle cream	0.149	6.9	46.4
Zebra colour	0.143	7.2	47.7
Black eye	0.151	6.9	51.6
Lsd (0.05)	NS	NS	NS
<u>Priming Regime(hrs) (PR)</u>			
0	0.134	7.7	49.0
6	0.146	7.0	47.6
12	0.156	6.5	51.1
24	0.157	6.7	46.5
L x PR	NS	NS	NS
Lsd (0.05)	0.021	1.1	5.4
CV (%)	16.7	18.6	13.3

At Wa, bambara groundnut landraces did not significantly affect (p>0.05) rate of seedling emergence (Table 4.2). Among the landraces, Burkina took the longest time (40.2days) to reach 50% flowering, and this was significantly higher than all other treatment effect except the Black eye .The treatment effect of the Black eye was significantly higher than that of the Mottle cream landrace. The treatment effects of the Mottle cream and Zebra colour landraces were similar. The Zebra colour landrace produced the greatest plant population at 50% emergence, and this was significantly (P<0.05) higher than that of Mottle cream landrace only. All other treatments differences were not significant at 5% level of probability.

Priming resulted in significant differences in rate of seedling emergence and days to 50% emergence (Table 4.2).Priming at 24hours resulted in higher rate of seedling emergence than the control treatment effect(P<0.05). All other treatment differences were not significantly (P<0.05) different. Additionally, priming at 24hours significantly delayed 50% flowering than priming at 12hours only. All other treatments produced similar effects.

Table 4.2. Effect of seed priming on Rate of seedling Emergence, days to 50% flowering, and Plant population at 50% emergence of four Bambara groundnut landraces at Wa.

Treatment	**Rate of Emergence**	**Days to 50% Flowering**	**Plant Population at 50%emergence**
Landrace (L)			
Burkina	0.154	40.2	86.8
Mottle cream	0.159	38.6	85.4
Zebra colour	0.148	38.9	87.9
Black eye	01.46	39.6	86.8
Lsd (0.05)	NS	0.83	1.95
Priming Regime (hr)(PR)			
0	0.142	39.3	86.5
6	0.151	39.3	87.3
12	0.154	38.8	87.0
24	0.159	39.8	86.3
L x PR	NS	NS	NS
Lsd (0.05)	0.016	0.83	NS
CV (%)	13.3	2.5	2.7

4.2 Plant population, Percentage plant establishment and Number of leaves and Canopy spread

There were no significant differences (p≤0.05) in the number of leaves, plant population and percentage establishment among the landraces on both sampling period (Table 4.3). The effect of priming on all the above parameters was also not significantly different on both sampling period (P≤0.05) (Table 4.3).

Table 4.3 Effect of seed priming on plant population, percentage establishment, and number of leaves per plant of four bambara groundnut landraces in Kumasi.

Treatment	Plant Population / $9m^2$		Percentage plant Establishment/$9m^2$		Number of leaves/plant	
Landraces (L)	**9 DAS**	**20 DAS**	**9 DAS**	**20 DAS**	**20 DAS**	**40 DAS**
Burkina	80.4	83.2	83.6	92.4	9.3	13.7
Mottle cream	78.4	79.2	81.1	88.0	9.0	14.3
Zebra colour	77.4	78.7	79.5	87.4	8.8	13.8
Block eye	77.8	79.3	81.8	88.1	9.0	14.4
Lsd (0.05)	NS	NS	NS	NS	NS	NS
Priming Regime (PR)						
0	75.6	78.5	80.8	87.2	8.9	13.2
6	78.5	80.7	82.0	89.6	9.0	14.6
12	79.5	79.9	81.5	88.8	9.1	14.9
24	80.5	81.2	81.6	90.2	9.1	13.4
L x PR	NS	NS	NS	NS	NS	NS
Lsd (0.05)	NS	NS	NS	NS	NS	NS
CV (%)	9.0	8.3	7.6	8.3	7.7	11.7

At Wa location, Plant population and percentage establishment on both sampling days were significantly ($p<0.05$) affected by bambara landraces (Table 4.4). Sampling at either occasion indicated that percent establishment was greater with the Zebra colour landrace, but this was significantly higher than that of the Mottle cream landrace only ($P \leq 0.05$). All other treatment differences were not significant. Data for plant population on both sampling days showed that, the Zebra colour landrace produced the greatest effect and this was significantly higher than the Mottle cream land race only. All other treatment effects were significantly similar. Priming did not have any significant effect ($p \leq 0.05$) on both plant population and percent establishment (Table 4.4).

Table 4.4. Effect of landrace and seed priming on percent establishment and Plant population of four Bambara groundnut landraces at Wa.

Treatment	**Percent Establishment/9m^2**		**Plant population/ 9m^2**	
	9 DAS	**20 DAS**	**9 DAS**	**20 DAS**
Landrace (L)				
Burkina	96.48	96.6	86.8	86.9
Mottle cream	94.92	95.5	85.4	86.0
Zebra colour	97.70	97.6	87.9	87.8
Black eye	96.50	96.5	86.8	86.9
Lsd (0.05)	2.18	1.81	1.95	1.59
Prime Regime (hr)(PR)				
0	96.12	96.5	86.5	86.8
6	96.96	96.8	87.3	87.2
12	96.69	96.9	87.0	87.2
24	95.84	96.0	86.3	86.5
L x PR	NS	NS	NS	NS
Lsd (0.05)	NS	NS	NS	NS
CV (%)	2.7	1.76	2.7	2.2

Leaf production at 20 DAS was not affected by landrace. However, at 40 DAS, number of leaves produced by the Mottle cream landrace was significantly lower than those produced by the Zebra colour and Burkina landraces. The canopy spread was not affected by the different landraces (Table 4.5). Biomass yield was greatest in the Black eye landrace, and this was significantly higher than the effect on Mottle cream landrace only. All other treatment effects were statistically similar. Priming did not significantly affect, leaf production, plant canopy nor biomass yield (Table 4.5).

Table 4.5: Effect of landrace and seed priming on the number of leaves per plant, plant canopy and biomass of four Bambara groundnut landraces at Wa.

Treatment	Number of leaves		Canopy Spread (cm)	Biomass (g/plant)
	20 DAS	40 DAS	60DAS	
Landrace (L)				
Burkina	13.00	28.40	46.03	9.8
Mottle cream	13.07	26.34	45.02	7.5
Zebra colour	13.27	28.27	47.38	8.7
Black eye	13.12	27.78	49.35	10.4
Lsd (0.05)	NS	1.88	NS	2.73
Prime Regime(hrs) (PR)				
0	12.23	27.08	46.36	9.0
6	13.65	27.03	47.66	8.9
12	14.03	28.33	48.79	9.4
24	12.53	28.34	44.95	9.1
L x PR	NS	NS	NS	NS
Lsd (0.05)	NS	NS	NS	NS
CV (%)	17.4	8.2	12.5	36

4.3 Yield and yield components

Yield data from the Kumasi experiment are presented in Table 4.6. Both grain yield (g/plant) and pod yield (g/plant) were not significantly ($p<0.05$) affected by landraces and priming regime. On the other hand, landrace type hard significant effect ($p<0.05$) on hundred seed weight. The greatest effect was measured in the Zebra colour landrace, and this was significantly higher than the treatment effects of Burkina and Black eye landraces only. All other treatment differences were not significantly different ($p\leq0.05$). Priming, however, did not significantly affect hundred seed weight.

Table 4.6. Effect of seed priming on grain yield, pod yield, and pod harvest index of four bambara groundnut landraces in Kumasi

Treatment	**Pod yield (kg/ha)**	**Grain yield (kg/ha)**	**100 seed weight (g)**
Landrace (L)			
Burkina	2530	2410	55.0
Mottle cream	3270	2870	51.5
Zebra colour	3160	2730	56.5
Black eye	2980	2540	53.4
Lsd (0.05)	NS	NS	NS
Priming Regime (PR)			
0	2690	2320	5O.6
6	2840	2520	51.2
12	3310	2780	57.4
24	3100	2930	57.1
L x PR	NS	NS	NS
Lsd (0.05)	NS	NS	NS
CV (%)	32	30.1	3.1

Yield data from the Wa experiment are presented in Table 4.7. Bambara landraces and seed priming did not significantly ($p \leq 0.05$) affect biomass yield at harvest and pod harvest index. However, grain yield (kg/ha) and pod yield (kg/plant) were significantly affected by both bambara groundnut landraces and seed priming.

Table 4.7. Effect of landrace and seed priming on grain yield, pod yield, biomass yield and pod harvest index of four Bambara groundnut landraces at Wa.

Landrace	**Grain yield (kg/ha)**	**Pod yield (kg/ha)**	**Biomass yield (kg/ha)**	**Pod harvest Index (H.I)**
Landraces (L)				
Burkina	736	1090	980	0.53
Mottle cream	706	1080	750	0.59
Zebra colour	722	1070	870	0.55
Black eye	862	1330	1040	0.56
Lsd (5%)	210	3.2	NS	NS
Prime Regime (hrs)(PR)				
0	798	1160	900	0.56
6	764	1150	890	0.56
12	845	1320	940	0.58
24	646	940	910	0.51
LxPR	NS	NS	NS	NS
Lsd (5%)	22	3.2	NS	NS
(CV %)	17.3	17.6	25.8	10.1

CHAPTER FIVE

5.0 DISCUSSION

5.1 Rate of Emergence and Days to 50% Flowering

Bambara groundnut remains a major food security crop cultivated mostly in semi-arid savannas of Africa. However, poor grain yield resulting from low seed viability, crop establishment, and differences in the germination abilities in landraces affect the potential of this legume as a food security crop. Landraces with hard seed coat inhibit moisture permeability and thus, affect germination rate (Linnemann and Azam- Ali, 1993; Berchie *et al.*, 2010). However, seed priming can improve germination, seedling emergence, plant establishment and and final yield (Harris *et al*., 1999; Rashid *et al*., 2002). However, Mabika (1991) found that pre-soaking bambara groundnut seed did not affect germination rate and rate of emergence. In this study, seedling emergence rate was not significantly affected by the landraces, but was significantly affected by the priming regime at both locations (Table 4.1 and 4.4). At the Kumasi location, priming for both 12 and 24 hours significantly improved seedling emergence over the control treatment. At Wa, priming effect was significant over the control treatment when priming was done for 24hour. Priming might have triggered some physiological factors affecting seed germination, and consequently increased the rate of seed emergence. Similar reports have been made by other workers (Rha and Jamil 2007; Rashid *et al*., 2002; Berchie *et al*., 2010). Seed priming was observed to reduce days to 50% emergence. Priming for 24 hours in this study resulted in all landraces reaching 50% seedling emergence within 6-8 days after sowing. In their study, Berchie *et al*. (2010a) reported that the landraces they studied reached 50% seedling emergence between 7-21 days after sowing. With the current unreliable rainfall pattern in Ghana, and virtually little irrigation practiced by peasant farmers who normally cultivate the crop, seed priming can assist the crop to emerge early and produce grain under drought. Harris *et al*. (2001b) earlier reported similar findings in different priming regimes in bambara groundnut. Other studies with sorghum, millet, cotton, beans and maize supported the view that priming induces early seedling emergence due to water imbibitions and reduced dormancy (Harris *et al.*, 1999; Rashid *et al.*, 2002; Murungu *et al*., 2004). Differences in days to 50% flowering at Wa among the landraces were not unexpected because of genotypic differences. However, reduction in days to flowering especially in Kumasi location can be a significant agronomic advantage to the landraces, especially with the current erratic nature of rainfall .In this study, the earliest flower initiation and development was 39 days .This agrees with the findings of Barlow and Haig (1987), Mauromical *et al*., (2000) and Harris *et al*., (2001b) who observed reduced flowering time with priming. Days to flowering were longer in Kumasi than at Wa (Table 4.1 and 4.4).Doku and Karikari (1970) reported that geographical location and season determine flowering in bambara groundnut .The length of the photoperiod has been reported as having serious effect on flowering. However photoperiod has been observed not to affect bambara production in Ghana (Kumaga *et al*., 2002, Berchie *et al*., 2010a).

5.2. Growth and yield

Plant growth is governed by a number of biological traits such as number of branches and leaves produced. Earlier studies showed that seed priming can affect the number of branches and leaves produced by a plant (Basra *et al*., 2003). In this study, priming affected number of leaves at 40 DAS at Kumasi location (Table 4.2). Even at Wa location, where treatment differences were not significant, priming improved leave production (Table 4.6). Where factors are conducive, increasing sink source through leaf production can result in higher yields (Gadner *et al.*, 1985). Results presented indicated that, all yield data (pod yield, pod harvest index and grain yield) were not significantly affected by seed priming. However, numerically, all priming treatments yielded greater than the control treatment for all the yield parameters. This shows that, priming has the potential of increasing yield in bambara groundnuts. Basra *et al.* (2003); Harris *et al.* (1999) and Rashid *et al*. (2004) have all reported that soaking seeds in water for extended periods resulted in increasing seed yield in bambara groundnuts. Berchie *et al*. (2011) have also confirmed from their studies that seed priming has the potential of increasing crop growth and yield. However, Ghana and Williams (2003) have cautioned that seed priming does not necessarily lead to increase in grain yield.

Hundred seed weight did not show any significant difference in Kumasi location even though 12 hrs priming recorded the highest hundred seed weight. However, in Wa location, priming at 24hrsbefore sowing, showed significant difference in the priming times among the four (4) bambara landraces but this was not the highest compared to priming at 0, 6 and 12hrs. This does not agree with Harris *et al*., (2001b) when they reported that direct benefits of seed priming in all crops included higher grain weight.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

The results of the study showed that seed priming enhanced germination, reduced time to seedling emergence and 50% flowering among the bambara groundnut landraces studied. All the growth and yield parameters were improved following seed priming. Among the priming times, 24hours of soaking seeds in water appeared to be the best in most parameters.

It is recommended that, the study should be repeated further using the same or modified treatments at different locations to validate the results.

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