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EVALUATION OF POTENTIAL BOTANICALS (*Virnonia amygdalina* and *Ipomoea batatas*) ON THE POST-HARVEST QUALITY CHARACTERISTICS OF FARMER-SAVED SEED MAIZE (*Zea mays* L.)

BY

SULLEY MOHAMMED (B.ED AGRICULTURE)

DECEEMBER, 2015

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A THESIS SUBMITTED TO THE SCHOOL OF RESEACH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECNOLOGY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS OF PHILOSOPHY DEGREE IN POSTHARVEST TECHNOLOGY

BY

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DECEMBER, 2015

DECLARATION

I declare that the work in this thesis was carried out by me, and that, it has never been submitted for a degree to any other university.

Besides the references made, which I have duly acknowledged, this thesis is the result of my own investigation.

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DEDICATION

This work is dedicated to my parents, Dawuda Osman and Fatima Osman with lots of love, respect and gratitude. Their loving concern has made my project work particularly and my education in generally a reality.

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ABSTRACT

This study was conducted in order to evaluate the potentials of two botanicals, bitter leaf (*Virnonia amygdalina*) and sweet potato leaf (*Ipomoea batatas*) on the postharvest quality characteristics of farmer-saved seed maize (*Zea mays* L.) collected from respondents in the study areas, that is, Ejura, Sekyedumasi and Nkoranza communities. The seeds were treated with the tested botanical materials and stored for a period of four (4) months. The plant extracts, also called botanicals were compared with a synthetic chemical (Insector T45) dust, as a standard, and without chemical treatment as controls

The same rates, 5.0% $^{w/}{}_{w,}$of each of the two plant extracts in powdered form and a synthetic chemical (Insector T45) at the rate of 0.25% w/w were admixed with one hundred grams seed lots of each of the five different seed maize varieties obtained across the study areas and packaged into high density polythene bags. Seed treatment with synthetic chemical and another without chemical treatment were used as a comparative control for the plant extract treatment. Results showed that all the two tested botanicals, *Virnonia amygdalina* and *Ipomoea batatas* have the ability to protect the seed maize quality characteristics during storage. This present finding or study recommend ground powder of bitter leaf (*Virnonia amygdalina*) and sweet potato leaf (*Ipomoea batatas*) as a good substitute to the synthetic chemical, insector T45, as a seed maize preservative during storage. The results are also discussed on the need to use plant extracts by resource poor small scale maize farmers as a sustainable and cost effective treatment application of stored seed maize as an alternative to synthetic chemical application treatment of seed maize during storage

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CHAPTER ONE

INTRODUCTION

Maize (*Zea mays* L.) is an important crop produced and consumed with increasing production since 1965 (Morris *et al.*, 1999). It is an important cereal crop in the developing and developed countries as a source of food (IITA, 2009). According to the international service for the Acquisition of Agro-biotech Application (ISAAA, 2010) estimate, worldwide production was 80 million tons in 2007. Over 150 million hectares of land in 2007 were planted with maize world wide with yield of 4.97 t/ha (ISAAA, 2010).

Maize is Ghana's second most staple food and it is grown by the vast majority of rural household. It is widely consumed throughout the country and it is second next to cassava, thus very important for food security (Adetiminrin *et al.*, 2008). Maize was one of the continental commodities, identified by the African Union Abuja Food Security Summit capable of enhancing food security at the continental and sub- regional level (AUC, 2006)

Maize contains about 70 – 72% digestible carbohydrates, 4- 4.5% fats and oil and 9.5 – 11% protein (Larger and Hill, 1991). Morris *et al.* (2001) reported that maize is an important source of carbohydrates in the tropics. Chaudhary (1983) , in a study asserted that Africans consume maize as starchy based in a wide variety of porridge, paste, grits and beer. They added that the green maize (fresh on the cob) is eaten parched, baked, roasted or boiled and that it consists of 72 percent starch, 10 percent protein, 4 – 8% oil, 8.5% fiber, 3.0% sugar and 1.7% ash.

Ghana is one of the major producers of maize, accounting for 9% of the total average among surveyed countries in Africa (Alene and Mwalughali, 2012).According to the Ministry of Food and Agriculture (MoFA, 2009) maize production in Ghana in the year 2009 averaged 1.7 million tones harvested from 990,000 hectares of land. They further pointed out that both total production of maize and land size devoted to maize cultivation has been increasing over the past.

Due to the importance of maize and the high level of cost and investment in its production, post harvest losses in the form of quantity and quality must be kept at minimum. This will go a long way to enable producers to maximize profits as well as increase productivity.

The maize production system in Ghana has so many constraints. Seed insecurity, mainly caused by storage pests and seed borne pathogens, contribute significantly to higher yield losses before and after harvest. Seed security is the way forward to the attainment of food security among resource poor small holder maize farmers in Ghana and therefore securing and conserving seed maize quality characteristics is an important management issue for farmers, policy makers, plant breeders as well as other key players in order to achieve food security.

Seed rot organisms and insect pests in their adult and pupa stages cause considerable losses to seed maize. The presence of insects and contaminants in seeds, downgrade its quality as well as the value and to some extent bring about an establishment or infestation including aflatoxins, thus making it unsuitable for food, animal feed or seed (Kling, 1991). Deterioration of seeds in storage is the fundamental reason for reduced productivity (Gras *et al.*, 2000).

To set up a healthy field that will give a good yield, healthy seeds are needed because seed borne pathogens bring about poor germination, poor vigour, poor crop establishment and crop stand, non-healthy plants, lodging and poor yield (Wiese, 1984). Farmer- saved seed maize planted predominantly by most farmers are infested with seed borne fungal pathogens (Tagne *et al.*, 2008).

Many efforts have been made by peasant maize farmers to preserve the post harvest quality characteristics of the stored seed maize. They employ a number of post harvest quality management intervention strategies such as open sun drying, storage in airtight containers, barns, earthen pots (or wares) and the use of synthetic chemicals to treat the seed maize (Golob *et al.*, 1990).

The treatment of maize seeds with synthetic chemical is a practice that is becoming more common among maize producers in Ghana. This is so because they are effective in protecting the physiological quality of seeds (Machado *et al.*, 2006).

Though synthetic chemicals seed maize treatment is effective and continue to play a leading role in the preservation of seed quality, there is a growing awareness and concern by environmentalist and health officials about the adverse effects of synthetic chemicals on users, consumers and beneficial organisms of plants (Chapman and Harris, 1981).

Moreover, storage pest and seed borne pathogens are increasingly becoming resistant to many synthetic chemical compounds (Golob *et al.*, 1990) and fewer synthetic chemicals are available because of increasing cost of their development and stricter regulation for their use (Scholler *et al.,* 1997). The growing concerns of the effects of synthetic chemicals have led scientist to develop botanical extracts as seed preservatives. Botanical extracts have great potentials as they are easy to be prepared and applied (Giridhar and Reddy, 1996).

Botanical extracts are safe and effective in view of being systemic in their action and they lack residual effect (Benharel and Jana, 2006). Plants extracts have been reported to be safe to beneficial organism such as pollinating insects, earthworms and human, (Rotimin and Moens, 2003). According to Khalid *et al.* (2002) the toxic effects of botanical extracts are normally of an ephemeral nature disappearing within 14 – 21 days and as such they are environmentally friendly.

Themain objective of this study was to determine the effectiveness of insecticide plant material as suitable seed treatment material to synthetic chemicals

The specific objectives were to;

(i) To determine the potency of sweet potato leaf and bitter leaf extract as seed treatment material.

(ii) Assess the post harvest seed management practices of maize farmers in study area that affect the quality of the famer saved seed maize.

(iii) To determine the inhibitory effects of botanical extract on seed rot organisms and insect pets on stored seed maize.

(iv) To evaluate the potential of natural products as seed preservatives.

CHAPTER TWO

LITERATURE REVIEW

2.1 Source of seeds to small-holder farmers

The most important factor in good crop production is the availability and use of certified and improved seeds in planting. High quality seed must be true-to-type, should be free from the presence of other seed species and seed borne diseases (Clottey *et al.*, 2009).

Such seeds must be high yielding, adaptable to the locality and must be preferred by the indigenous farmers (Guberac *et al.*, 2003). A good quality seed must score high in terms of the proportion which under strictly defined conditions is most likely to emerge from the soil and be able to sustain autotrophic growth (Scowcroft and Scowcroft, 1998).

Seeds are considered the least of all the input of farmers as observed by the association of official seed certification agencies (AOSCA, 2003). Nevertheless, they are the most important relative to all the factors that determine the final yield of crops and the part played by higher quality seeds in cause of human and agricultural development cannot be overemphasized (Cromwell *et al.*, 1993; Lanteri and Quagliott, 1997).

Farmers in Ghana plant uncertified seeds saved by neighbours or bought from the local grain market or from their own saved seeds from previous harvest factors that lead to the spread and introduction of diseases to new areas (Walker *et al.*, 1997a). This disturbing trend has been attributed to several factors such as higher cost of certified seeds, fear of losing the traditional variety that farmers belief have unique characteristics, desired to grow new varieties best suited to the local climate and soil conditions (Anon, 2007).

About 80-90 % of farmers in sub-Saharan Africa obtain their seeds from informal sources (Almekinders *et al.*, 1994).

Sixty percent of farmers who are engage in vegetable production recycle seeds from their previous harvest with only 30 % of them obtaining the seeds from certified seed dealers in Nigeria (Adetumbi and Daniel, 2004). Forty percent of farmers in the developed countries obtain their seeds from the informal source (Anon, 2000a).

2.2 Seed Quality

Quality according to the end user refers to the characteristics, attributes and the intrinsic value of a commodity that makes it acceptable to the final user (Hampton, 2002).

Generally, seed quality is defined as the level of measure that determines the performance of seeds when sown or stored (Ellis, 1991). Several other factors such as variety, presence of seed borne disease, vigour of the seed as well as the size,are all important parameters used to determine seed quality (Hampton, 2002).

According to Copeland and McDonald (1995), a good quality seed should meet certification standards such as genetic purity, uniformity, conformity to standards of a particular cultivar, freedom from diseases and mixtures of seeds of other crops and inert materials.

Seed quality is a term that embodies all seed quality parameters, such as seed health, varietal or physical purity, germination potential, speeds of germination and size of seeds (Healtherly and Elmore, 2004).

2.2.1 Seed Purity

Seed purity, also referred to as crop purity, means that the seed is free from contaminations including seeds of weeds, other crops and inert materials. Seed purity is measured by the amount of unwanted materials that are present in pure seed lots as pointed out by the association of official seed citification agencies (AOSCA, 2003).

The presence of contaminants in pure seed lots does not only influence the cost of production but also, to a large extent, reduce the quality and quantity of the crop harvested (Rindels, 1995).

According to Simic *et al.* (2004) seed purity can be looked at from two angles, seed genetic purity and crop physical purity. Seed genetic purity is inherited in the variety and has an influence on the maturity date, disease and insect resistance, nutritional and general characteristics of the crop. Protecting the genetic purity of a seed depends on accurate keeping of records, use of clean equipment and good handling. Crop physical purity on the other hand implies that the pure seed lots are free from unwanted materials such as inert matter, other crop seeds among others. The planting value of seeds is determined by the use of pure seed lots together with the germination potentials of the seed as reported by international institute of tropical agriculture (IITA, 2009).

2.2.2 Seed Vigour

Seed vigour is an estimate of the potential ability of the field performance and eventually the field planting value of seeds (Copeland and McDonald, 1995)

Seed vigour is the aggregate of all those properties, activities and the performance of the seed during germination and Seedling emergence in a broad range of environment (Caddick, 2007).

According to the International Seed Testing Association (ISTA) (2007) all the factors that determine the potential extent of the activities and the performance of seed germination and emergence are the indicators of seed vigour.

Seed vigour is one of the important parameters used to measure seed quality and can influence seedling establishment, much especially, under adverse environmental conditions (Ghassemi-Golezani, K. et *al.*, 2010).

Seed vigour is an important factor that often results into seedling establishment and for this reason seeds with low vigour generally produce weaker seedlings that are susceptible to environmental stress while seeds with high vigour can provide for early and uniform stands which give the seedling the competitive advantage over all other environmental factors (Harrington, 1972).

The effect of seed vigour on crop stand establishment can be critical to crops that require spatial distribution of plants in order to maximize yield (Tekrony and Egli, 1991) and delayed or lower seedling emergence in this respect may reduce crop yield at harvest.

2.2.3 Seed Germination

Germination is the emergence and development of a seed embryo those important features which together make up the seedling and at the same time serve as an index for assessing the potential ability of the seed to develop into normal plant under suitable conditions in the soil (Barua *et al.*, 2009).

Germination is the most important function of seed because it is an indicator of its viability and growth and the need for the assessment of the ability of seeds to germinate is aimed at comparing the value and fixing or determining prices for different seed lots and advising on the plant producing ability of the seed (AOSA, 1999).

Through germination, seedlings that are abnormal are easily detected and at the same time the degree of dormancy and freedom from presence of other species of crops is evaluated (Viera *et al.*, 1999)

There are many factors used to determine seed germination, and this includes growth rate and viability (Detroja *et al.*, 1993). Rapid emergence of seedlings from quality seed lots lead to the production of larger and vigorous seedlings (Ghassemi-Golezani *et al.*, 2008).

Germination is often the only kind of test that a farmer can perform on the seed prior to planting and checking the time taken by seeds to germinate will certainly give the measure of the speed of germination (Byrum and Copeland, 1995).

The purpose of seed germination test is meant to provide a first and final count. The primary purpose of the first count is to determine the number of strong seedlings that have germinated while the final count is to allow enough time period for weaker seeds to be considered as having germinated (Vindhavarmann *et al.*, 1990; Byrum and Copeland, 1995).

The seed germination test is expressed as the proportion of the total number of seeds that are alive and it is determined through controlled test and actual count of the number of seeds that germinated (Byrum and Copeland, 1995).

2.2.4 .Seed Health

Seed health is a measure of the presence or absence of seed borne pathogens that exist on or in seed. According to Mathur and Kongsdal (2003) seed health is the evaluation of seeds for the purpose of finding out the presence or other wise of seed borne pathogens such as viruses, fungi, nematodes and insect pest in order to establish the standard of the quality of seeds within a seed lots. Mew and Gonzales (2002) asserted that when disease causing pathogens occur in seed lots, they affect the health status of the seeds. Seed borne pathogens as well as insect pest compete with the crop seed for nutrients. Other contaminants such as debris and soil particles downgrade the quality of the seed (Mew and Gonzales, 2002).

The economic importance of seed borne pathogens cannot be overstressed. When crops are grown out of seed borne pathogens, considerable crop losses occur (Tagne *et al.*, 2008).Prasad and Kulshretha (1991) established that sunflower seeds infected naturally or artificially with *Alternaria helianthus* (auth) showed up to 32.8 % reduction in germination. Wanyera (1998) in a study analyzed that fungi infection lead to the abnormal seedlings and dead seeds.

The main aim of seed health test is to ensure sowing of only healthy and pure seeds in the field leading to the production of healthy food and seed crop and higher yield in terms of both quantity and quality (Holbrook *et al.*, 2000).

2.3. Quality of Farmer-saved seeds in Ghana.

Many farmers in Ghana plant uncertified seed saved from their own previous harvest or saved by neighbours or purchased from the local grain market, practices that encourage spread and introduction of new disease (Maredia *et al.*, 1999).

This trend has been attributed to unavailability of certified seeds, the fear of losing the traditional varieties that farmers believe have special attributes (Danquah *et al.*, 2007). However, the qualities of farmer-saved seeds have been rejected by researchers, plant breeders and policy makers (Tagne *et al.*, 2008).

Farmer-saved seed production system appears to ignore some quality aspects and, therefore, the danger of degradation of seed quality and eventually the expected yield is imminent (Tagne *et a*l., 2008). According to Praveen *et al.* (2001) farmer-saved seeds are generally below standard in respect to seed vigour and seed health status.

Hemanth *et al.* (2007) in a study involving cowpea and Paddy sorghum reveal that 28 different genera of fungi were associated with these crops and generalized that farmer-saved seeds were poor in health status. A number of factors, including how the seed is stored, are responsible for the occurrence of mycoflora (Hemanth *et al.*, 2007). The inability of maize farmers to cope with productivity demand is caused by low adaptation of productivity enhancing technologies that include improved varieties and management practices as well as low patronage and the use of input of higher standards (Tripp and Dankyi, 1997). Farmer-saved seeds that are planted by most farmers are observed to be infected with seed borne fungi pathogens (Tagne *et al.*, 2008).

However, the physical purity of farmer-saved seeds has, in some instances, been reported to be quite higher. According to Hanque *et al.* (2007), the physical purity of farmer-saved seeds could be as high as 96.1% for the pure seed lots component. A similar observation was made by Mekbib (2008) that the physical purity of farmer-saved sorghum seeds was quite higher except for the fact that it fell below in respect of varietal purity level. Walker *et al.* (1997a) observed that up to 25% of farmers in Ghana attributed poor field germination of cowpea to the use of low or poor quality seed in sowing. A related observation made by Hanque (2007) revealed that poor field germination of rice was largely attributed to the use of low quality seeds used in sowing.

2.4. Deformed Seed (ShriveledSeeds) and Their Effects on Growth and Yield

Maize seed size of all varieties is connected to two factors, the genotype and the environment in which they are grown. These two factors play an important role on the survival and the eventual growth and the development of the crop (Nerson, 2002).

Certified seed production companies and breeders separate seeds into small, medium and large size fraction commonly referred to as fractionation based on thousand kernel weight and the endosperm of the seed in question (Sulewska, Koziara, 2006)

Much research work has been conducted in the 21st century on the effects of seed size and early growth of crops and have reported that there is a correlation between the size of seeds, seedling vigour, improved establishment as well as higher productivity among plants grown out of large seeds when compared with crops grown out of smaller seed size in a typical cultivar (Nik *et al.*, 2011)

Seed size plays an important role, among other factors, during the process of germination and it is generally associated with seedling vigour which is considered as an important factor for the future of the crop plant (Nerson, 2002).

Seed germination and seedling vigour are together much influenced by the size of the seed used in planting. Research by Nerson (2002) showed that large seed sizes of a given variety of crop were associated with high field germination capacity and that seedlings had greater weight as compared to those planted out of smaller seed size.

According to Goggi *et al.* (2008) seed quality is an important factor that determines the early development and growth of agricultural crops and for this reason all studies to improve yield and nutrition of plants must take into account the quality of the seed. The sizing of crop seeds also called fractionation is based on the understanding that some of the physical characteristics of seeds affect the vigour and seed sizing is the quality characteristics (Sulewska, Koziara,2006)

Royo *et al.* (2006) in a study indicated that the yield of durum wheat plants grown from large grains was higher by 16% compared with that from plants grown from small seeds. Similar results were obtained by Nerson *et al.* (2006) in an investigation in which large seeds produced greater plot stands.

Also Rukavina *et al*. (2002) obtained a significantly higher yield from planting large seeds rather than smaller seeds regardless of spring barely cultivars.

A study by Gholizadeth *et al*. (2004) showed that by increasing maize seed size the commercial yield increased and the seeds with higher vigour produced stronger seedlings, thus increasing the establishment rate of the seedlings and creating a better green cover in the field which finally produced more vigorous plant.

2.5. Seed Borne Diseases and Insect Pests of Seed Maize and Their Effect onGrowth and Yield

Seed borne disease and insect pest can affect the crops and have a serious impact on the growth and yield of the crop. Seed borne diseases of maize that are caused by fungi include late wilt, black bundle disease, false head smut, head smut *Gibberela* stalk rots and *Fusarium* (McGee, 1988).

Alternaria leaf blight, *Acremonium zeae* stalk rot, horse's tooth, mildews, *Botryodiplodia* or black kernel rot, common smut, gray ear rot, *Nigrospora* ear rot, charcoal ear rot, *Penicillium* ear rots and *Anthracnose* stalk rot are other diseases of maize (CIMMYT, 2004)

Meanwhile, among the diseases mentioned, sorghum downy mildew, *Anthracnose* rots, Philippine downy mildew, black bundle, *Penicillium* ear rot, horses tooth, downy mildew, *Nigrospora* ear rot, and java downy mildew are seed borne in nature and spread through seeds (McGee, 1988).

Seed borne diseases are influenced by the age of a plant and the environment (Andele and Cardwell, 2000). Affected plants show chlorotic stripping on leaves and sheaths and plants become dwarfish (CIMMYT, 2004).

Seed borne diseases induced tassel malformation, blocking pollen production formation (CIMMYT, 2004).

According to Johal *et al*. (2004) seed borne disease, cause serious economic losses. The diseases kill the plants near flowering and are mostly common in humid, heavy soil in hot areas (Johal *et al.,* 2004). Plants infected do not usually show any symptoms till they reach tassel stage where they start to wilt beginning from the top leaves eventually producing ears with underdeveloped shrunken kernels (CIMMYT, 2004).

Reid and Zhu (2005) indicated that in seed borne infected plants, there is premature wilting due to the complete destruction of the pith tissue with shredded vascular bundles turning dark brown.

Andele and Cardwell (2000) in their study of maize found that seed born pathogens invade seedling roots after flowering and when the plant reaches maturity the internal parts of the stem exhibit a black discoloration and vascular bundles shred.

Insects, most often, are mainly accused of been the main cause of maize grain losses (Adams and Schulter, 1978, Ali *et al*., 2007). Emana and Tsedeke (1999) observed that insect pest that causes damage to maize both in the field and during storage are *lepidopterous* stalk borer and *Coleopterous* weevils. A study by Abraham (1997) showed that more than 37 species of arthropod pests are associated with maize grain in storage.

According to Dubale (2011), most of the insect pests that cause damage to maize both in the field and in storage occur when the maize grain harvested are stored on the farm where post harvest management aimed at controlling pest are inappropriate thus resulting into large quantities of maize grain losses to pests of the stored grain.

The general worldwide picture of losses of grain and pulse crops after harvest is approximated to be 12% usually due to insect pest and this is quite serious in the developing countries (Boxall *et al.,* 2002). In a related study, FAO (1985) estimated that storage pests and lack of proper storage methods cause losses of 200 million tons of grain each year. The annual grain losses in Ethiopia range between 2 and 30% (Firidissa, 1999)

2.6. Control ofSeed Borne and Insect Pest of Seed Maize

Seed borne diseases and insect pests are controlled mostly by the use of seed treatment practices. A study by Neergaard (1988) revealed that the practice of seed treatment is the oldest practice in the protection of plants and the origin dates as far back to the 18th century where brine was use for the control of cereal smuts.

The use of modern seed treatment in recent times began with the discovery and use of organo-mercury fungicides in 1912 which were commonly used for several years (McGee, 1995)

2.7 Types of Control

The type of seed treatment can broadly be categorized as physical, biological, chemical and botanical

No matter the type of seed treatment in question, an acceptable seed treatment practice must satisfy all the following biological requirements (McGee 1995)

- Should not produce harmful residue on plants or soil
- Must be safe to wildlife
- Must be safe to the operators during handling
- Must be compatible with other materials used on seeds
- must be consistently effective
- The chemical or biological methods should have desirable qualities with respect to application and retention on the seeds

2.7.1 Physical Control

Physical seed treatment method is described as one of the ecologically friendly approaches and it is very effective when compared to chemical treatment especially the use of hot water but has the disadvantage of causing the loss of seed viability (Erdey *et al.*, 1997). The physical treatment mostly involves the application of heat to kill pathogens in seeds while ensuring that minimal damage is done to the seed tissue in the process. Hot water treatment has been used since the 1920's and before the discovery of systemic fungicides in the 1960's was the only available treatment to eliminate deeply infected seeds (McGee, 1995). The use of hot water seed treatment is continuously being exploited for the elimination of internal infection by *Xanthomonas campestris, PV malvacearum* in cotton (Honervogt and Lehmann-Danziger, 1992). McGee (1995) reported that hot water seed treatment has drawbacks in the sense that it is unable to completely eradicate bacteria infections considered as low but significant in terms of epidemiology, such as *Xanthomonas campestrisand campestris* in cabbage

Also Wang and Davis, (1997) in a study of hybrid cabbage seeds indicated that hot water treatment adversely influenced germination of seeds. Smit and knox Davies (1989) reported the opposite effects of hot water treatment on germination of *rooibost tea* seeds and proved that it was minimal without compromising the effectiveness and efficacy of seed borne pathogen control by minimizing the length at which seeds are kept in hot water and preceding the application treatment with scarification. Studies involving the use of vegetable oil seed treatment by Erdey *et al.* (1997) found that *phomosis* infection of soya beans seeds was controlled. Also (Neergaard 1988), in a study carried out on seeds involving dry heat application observed that it completely eradicated mainly bacteria and fungi pathogens.

The use of low electronic beams as a treatment technique was found to eliminate *Tilletia* carries and *Septorianodurum* from testa of seeds without affecting germination adversely (Burth *et al.*, 1991)

2.7.2 Biological Control Agent

The concept of using natural occurring beneficial bacteria and fungi organisms to control or check the activities of other bacteria and fungi is not a new practice and it is generally referred to as biological control (Pal and Mcspadden, 2006). According to Harman and Nelson (1994) biological control of plant disease, generally, has a record of inconsistency which has limited its practical use. Callan *et al.* (1997) in their study of biological control reported that due to the renewable interest in the environment and the establishment of the interest of workers protection and welfare standards, much research in to biological control is on going. similar reports were made by Harman and Nelson (1994) in a study on chemical pesticides in which they indicated that public growing awareness of the harmful nature of chemical pesticides over the last two decades have stimulated scientist to find biological control solution to pests. There are different kinds of biological agents that used to treat seeds currently at different stages of development (pal and Mcspadden, 2006).Studies are being carried out on *Gleoclaldium* and *Trichoderma* together with the *Actinomycetes streptomyces* potential seed treatment. Zhang *et al*. (2011), obtained progressive results in their recent study on biological control of seed borne diseases. Their investigation has proved that treating cotton (*Gossypium hirsutum*) seeds with the G-4 and G-6 strains of *Gleocladium virnes* and the GB03 and GB07 strains of *Bacillus sustilis* suppress the incidence and extent of severity of *Fusarium* white of cotton (*Gossypium hirsutum*) heavily infested with *Meliodogyne incognita*, v*asinfectum* f.spp and *Fursarium oxysporium* under special conditions such as green house conditions. Similar results were obtained by Milus and Rothrock (1997) in an experiment with winter wheat seeds with three bacteria strains helped to minimize *Pythium* root rot incidence in a growth chamber assays. Also schroth and Hancock (1981) reported an increased in yield in many types of crops with *Pseudomonas* seed treatment. Their investigation suggested that the success of the treatment application originated from displacement of root-infecting fungi and bacterial that generally reduced plant growth. For any biological seed treatment to be effective a number of factors have to be fulfilled and these include the inoculum density of the bio control agent which must be sufficient to over shadow and suppress disease under field condition and high levels of disease pressure, the formulation of the agent of biological control must allow or permit for an adequate shelf life and it must be friendly with other agents of biological control as well as chemical in the seeds and soil. According to Cook (1993) there are many microorganisms with potentials to serve as biological control agents which can be made available for seed treatment yet many bottlenecks work against the realization of this objective.

2.7.3 Chemical Control (Use of SyntheticChemicals)

Chemicals seed treatment is the application of chemical compounds to seed for the purpose of controlling, reducing or repelling disease or disease causing organisms or pathogens, including insect pests (Lead bitter *et al*, 1994), pests that are commonly associated with seed include rot- rotting of seed before germination, damping-off and seedling blight-soft rot of stem tissues near ground leaves (Reigart and Roberts 1999). Disease organisms of crop plants include *Phythium* species, *Fusarium*, *Diplodia*, *Penicillium*, *Helminthosporium*, *Ustilago* (smut) and *Rhizoctonia* (Reigart and Roberts 1999). Synthetic chemicals must always be used with caution because of their toxic nature and before they are used, it is very important to study and analyze the information about the product. The label always contain detailed information about the product such as the active ingredients, inert ingredient, warning statement including danger warning symbols, antidote, types of seed and rate per bushel, kind of pest or organisms controlled, care in handling and use of treated seeds, disclaimer or warranty clause (Lead bitter*et al*. (1994). Chemical seed treatment such as the use of Thiram and Captan on world wide basis has been reported.A study by schwinn (1994) indicated that in the year 1991, the use of synthetic fungicides in the treatment of seeds dominated globally representing 68%

share of all synthetic chemicals, followed by insecticides which recorded 11%. According to Wang and Davis (1997), Chemical seed treatment such as the use of Thiram and Captan is very effective in protecting the physiological qualities of the seed during storage.

The synthetic chemicals, fungicides and insecticides, presently used globally today are very different from those used in the past (Reigart and Roberts, 1999). The main synthetic chemicals of fungicidal and insecticidal properties are the organo-mercurial and dithiocarbamates such as Thiram and heterocyclic such as Captan, these worked by the direct contact with the pathogens or the host (Reigart and Roberts, 1999). Most of the past synthetic chemicals are now prohibited and banned in most countries because of their levels of toxicity and their harmful nature to the environment, human and animal health (Reigart and Roberts, 1999). Before the cancellation of the previously used synthetic chemicals called volatile mercurial, fungicides for treating seeds were generally classified as volatiles and non-volatiles and with the elimination of the volatiles mercurial, most fungicides approved for use on seeds are classified as non-volatiles and when used, complete coverage of the seed is required to obtain effective control (Reigart and Roberts, 1999). Synthetic chemical such as fungicidal seed treatment may be broadly classified into three categories depending on the nature and purpose of the treatment (Reigart and Roberts, 1999). According to Morton and Staub, (2008) the categories of fungicidal seed treatments include seed disinfection, seed disinfestations and seed protection.Seed disinfection is the elimination of a pathogen that has penetrated into living cells of the seed and thus infecting it and becoming established. Seed disinfestations is the control of spores and other forms of pathogenic organisms found on the surface of the seed and seed protection is a chemical treatment to protect the young seedlings from pathogenic organism. In the soil (Morton and staub, 2008)

2.7.4 Effects of chemical seed treatments

The expectations of having chemical compounds that would be able to move inside the seed or a plant and to control pest and pathogens has been recognized (Pedersen e*t al.*, 1986), such materials are called systemic and when they are used according to the manufactures'recommendations, a systemic chemical compound moves through the host plant material and retard the growth of certain fungi.

The overall effects of seed treatment are among other factors that affect the benefits of seed treatment in most crops (McGee, 1995). According to Pedersen *et al.* (1986), seed treatment with fungicides is reported to be very effective in protecting seeds from pest and rot organisms both before and during storage in the agricultural industry. In a related study, Wang and Davis(1997) ,showed that chemical seed treatment is important as it ensure stand establishment in the corn Belt of the U.S.A. Thiram which are the main part of seed treatment chemical for the treatment of most species of crops have a broad spectrum action against pest and seed rot causing pathogens (Morton and Staub, 2008).According to Lead bitter *et al.* (1994) ,synthetic chemical compounds are effective in controlling, reducing or repelling diseases and disease causing organisms including insect pest. The cancellation of volatile chemical compounds and replacement with non-volatile compounds in recent times has triggered investigations into the effectiveness of no-volatile compounds in treating seeds (Richardson, 1986). In all these findings, effects of the treatments on the final yield of crops have not been significantly different from seeds that were not treated with chemicals. Brodal (1993) reported the opposite and find a significant difference in yield of crops for which seeds were treated with synthetic chemicals as compared with those for which the seeds were not treated. According to Lead bitter *et al.* (1994) the poor efficacy of chemical use to treat seeds has a bearing on lack of skills expected to apply and handle these chemicals on the part of the users.

2.7.5 Raw Plant or Botanical Extracts With Phytochemical Properties

The downfalls of synthetic chemicals seed treatment has led to much effort in the areas of research worldwide, to evaluate the potentials of plant extracts in controlling insect pests and seed borne diseases of crop plants. A study by Chatterjee (1990) showed that the oils extract of clove and *cassia* produced an inhibitory effect on the growth and establishment of seed borne infections of *Aspergillus flavus* and *Chaetomium indicum* in maize. A related study demonstrated that extracts of *Dennettia tripetala* effectively checked the growth, development and spread of *Sclerotium rolfsy* induced rot of corms of cocoyams (Nwachykwu and Osuji, 2008). According to Shetty *et al.,* (1989) Neem tree (*Azadrachta indica*) contains Azdirachtin which is believed to have antifungal characteristics. Similarly, *Fusarium oxysporium* and *Rhizopus stolonifer* among other pathogens were also reported to be inhibited by extracts from *Chromolaena odratum, Azadrachta indica, virnonia amygdalina* and *Tradex procumbens*. Alice and Rao (1986) reported that garlic bulb extracts inhibited the spore germination and mycellial growth of seed borne fungi pathogen of jute. Similarly, McGee *et al.* (1989) indicated that soya bean oil applied at a rate used inhibited and suppressed grain rust, reduced storage fungi growth in maize and soya bean during 12 months in field storage bins in Iowa.

2.7.6 Effects of Ipomoea batatas (sweet potatoes) leaf extracts on insect pest and seed borne pathogens of seeds

Sweet potatoes are a member of the family convolvulaceae. It is today known by the botanic name *Ipomoea batatas* (Scott, 1992)

Sweet potato contains a broad range of botanical active secondary bioactive metabolites which includes alkaloids, flavonoids, tannins, saponins, phenols, Polypeptides, Quinone, lectinins, and steroids (Knoczak *et al.*, 2003)

A study by knoczak *et al.* (2003) indicated that the roots and skin of sweet potatoes contains high levels of polyphenols such as anthocyanin, phenolic acids and caffeic acid.

Caffeoylquinic acid derivatives such as chlorogenic, dicaffeoylquinic and tricaffeoylquinic acid are found in the roots that protect them from fungal and have potential cancer chemo protective effects (knoczak *et al.*, 2003; Konczak *et al.*, 2004; Goda *et al.*, 1997), Several reports have indicated that sweet potatoes displayed antioxidative or radical – scavenging activity and exerted several health promoting functions (Konczak-Islam *et al.*, 2003; Rabah *et al.*, 2004; Suda *et al.*, 2003). The red-fleshed sweet potato cultivar grown in the Andean region has been reported to have higher antioxidant activity and phenolic content than a cultivar of blue berry, a fruit with higher level of antioxidants (Cevallos and Cisneros, 2003).

This, they pointed out further, could suggest the potential that sweet potato leaves possessed a cheap source of natural antioxidant

According to konczak- Islam *et al.* (2003) the leaf of sweet potatoes extracts have radical scavenging activity, antimutagenic, anticancer and antibacterial activities. These protective properties, they observed further, might be attributed to the presence of the high levels of polyphenols and flavonoids compounds. The antioxidant activity of sweet potatoes however, was found to be linearly proportional with phenolic compounds (Oktay *et al.*, 2003).

Ghasemzadeh *et al. (*2011) in a related study reported a strong positive relationship between antioxidant activities which normally appears to be the trend in several species of plants.

The major phenolic compounds in a 70% methanol extract of sweet potatoes exhibited a strong antioxidant activity in linoleic acid aqueous system (Hayase *et al.*, 1984)

Kazuko *et al*. (2010) indicated that the purple sweet potato color and anthocyanin foods have been shown to offer protection against a variety of degenerating diseases processes.

The immature roots and leaves at the initial stages of growth have the highest concentration of phenolic and antioxidant activity (kazuko *et al*., 2010)

Pharmacological properties owing to the large variety of constituents of the sweet potato plant has been implicated in the treatment of more that ten pharmacological conditions (Dini *et al.*, 2006; Oki *et al.*, 2001). The antioxidant potentials of sweet potato is due to the presence of beta –carotene, anthocyanin's, caffeoyldautic acid and caffeoylquinic acid derivatives (Dini *et al* .,2006; Oki *et al.*, 2001)

The higher scavenging activity of sweet potato leaves was also confirmed in the study by Yang *et al.* (2005) in which the leaves of sweet potatoes ranked the first place with higher radical scavenging activity among 23 commonly consumed vegetables in Taiwan

Aside the total phenol and total flavonoids, the phytochemical,anthocyanin, also contribute to the high antioxidant activity of sweet potato (Islam *et al.,* 2003). Antioxidant properties of sweet potatoes and the preparations made from the leaves have powerful antioxidant activity associated with its alpha- to – cophenol content which is the most common form of vitamin E and composedof 25Mg per 100g of sweet potato shoots(Ching *et al*., 2001). In a study, *kwon et al. (2000*) reported that sweet potatoes leaf extracts have antiviral activity due to the presence of caffeoylquinic acid derivatives

The phytochemical potentials of sweet potatoes should it be investigated and confirmed, the abundance of this natural fungicide which can easily be grown, processed and administered by farmers themselves could help in promoting global agriculture to ensure food security.

2.7.7. Effects of *Virnonia amygdalina* (bitter leaf) on insect pest and seed borne pathogens

Numerous of the researches on the phytochemical potentials of *Virnonia amygdalina* (bitter leaf) have confirmed that bitter leaf contains bioactive metabolites. According to Erasto *et al. (*2006) bitter leaf is abound with phytochemicals and some of these identify in their studies include sesquiterpene lactones, Vernodalot, Vernolepin, Vernodalin and hydroxyl vernolide. In a related study, Igile *et al*. (1994) reported of the presence of flavonoids, luteolin and luteolin 7-0-B-glucoroniside in the leaves of bitter leaf. Many other researchers, (Udensi *et al., 2002; Tona et al., 2004*) have also confirmed the presence of flavonoids in the plant.

Additional phytochemicals present in the leaves of bitter leaf are terpenes, coumarin, phenolic acids, lignans, xanthones and anthraqunones (Wall *et al.*, 1998; *Tona et al.*, 2004*)*

A study by Izevbigie (2003) indicated that bitter leaf contain bio- active peptides called edotides and these phytochemicals and probably some others yet to be identified are believed to be accountable for the plethora of bio-activities possessed by plant.

These plethora bio-active principles may work together to produce the result for which the medicinal value of bitter leaf has been thoroughly studied (Izevbigie, 2003)

According to Ogbebor *et al*. (2005) the leaves extracts of bitter leaf have antifungal activities which can inhibit the growth of *Fusarium moniliforme* on seeds of maize (*Zea mays*) as well as *Mycellial* and *conidal* growth of *Colletotrichum gloeosporiods* in rubber trees. In a similar study extracts and powder formulation of bitter leaf effectively checked the growth, development and spread of *Rhizopus stolonifer* and *Fusarium oxysporum* pathogens, *Penicillium digitatium*, *Micorpiriforms, Aspergillus Niger* and *Heminsthoporum solani*.

Wedge *et al.*(2000) reported that leaves extracts from the bitter leaf plant showed to be potent against plant fungal pathogens while not affecting the growth of plant adversely. However, Akinpelu (1999) observed that a 60% methanolic extract of bitter leaf had no effect against *Candida albicas*, a popular opportunistic pathogen of human Vernolide but on the other hand shown to have activity against the fungi *Aspergillus flavus,* mucor hienalis, *Fusarium oxysporum*, *Penicillium digitatum* and *Aspergillus niger* in a manner that is comparable (at 0.1mg/ml and above) to the standard drug Nystatin (Erasto *et al.*, 2006)

In another development, dust from the dried leaves of bitter leaf were also found to have insecticidal potency against the larvae of *Callosobruchus maculates* and *Sitophilus zea mays* insects that cause considerable losses of stored cowpea and maize respectively(Kabeh and Jalingo, 2007) .Fungi and insect pests are major challenge confronting developing countries, they cause diseases in man and plants as well as animals(Schwin, 1982) and botanicals may be quite useful in the management as well as control of insect pest and seed borne diseases much especially since they are abundant, easy to prepare and apply coupled with the fact that they are environmentally friendly

2.7.8. Effect Of Insector T 45 (Imidaclorid 350g/Kg + Thiram 100g/Kg: DS) On Seedborne And Insect Pests Of Maize

Seed treatment with fungicides is a common practice that is expected to prevent seed born disease caused by pathogens.

Moreover, to avoid damage caused by insect pests, combinations of fungicides with insecticides have been employed, resulting into a considerable increase in the number of chemicals compounds used in seed treatment.

In Africa, pesticides use accounts for 4% of the global pesticide market of 31 billion United States dollars (Agrow, 2006; PAN, UK, 2006).Studies suggest that some farmers mix cocktails of two or more insecticides (Biney, 2001) aimed at increasing the efficacy of these chemicals. The need for better seed treatment has led to the formulation of different chemical ingredients in a single seed treatment (Williamson *et al*., 2008).

One such product is insector T 45 which contains imidacloprid 350/kg + Thiram 100g/kg: DS. Insector T 45 has a broad spectrum of efficiency against sucking insects (aphids, leaf hoppers among others), coleopterans, few Lepidoptera and Dipteran. It also allows the inhibition of a large number of fungi .Chemicals control of insect pests and seed borne pathogens using a broad spectrum chemical compounds is the most commonly used and recommended management approach (Greenberg *et al* ., 2009).

Many vegetables and maize farmers depend on the use of pesticides and fungicides to control insect pest and diseases (Biney, 2001). According to Taylor *et al*. (2001) the use of broad spectrum chemical compounds for seed treatment is a highly appreciable and progressive technology for the management of many crop pests and seed born pathogens.

Imidacloprid, the first active ingredient in insector T45, is a systematic insecticide belonging to the chemical class neonicotinoids which acts by specifically blocking the microtinergic neural pathway of insects (Jemec *et al.*, 2007). Neonicotinoids pesticides were first registered for use in the mid 1990s and since then, these chemicals have become widely use on farm crops, ornamentals, land scape plants and trees.(Jemec *et al* 2007).

Generally, neonicotinoids are systematic chemicals; they are mostly absorbed by plants and transferred through the vascular system making the plant itself toxic to insects. The long lasting effect of neonicotinoids on plants offer a great promise for the long term plant protection (Jemec *etal*., 2007) for they are absorbed by and get inside the treated plant protecting it from sap – sucking insects and those that chew on it.

A study by Zhang *et al*. (2011) indicated that the use of imidacloprid seed treatment was effective in suppressing the whitefly population in cotton field .In a related study, Lind *et al*.(1998a – 1998b) reported that imidacloprid is a broad spectrum chemical that kills insects, fungi, and other seed borne pathogens.

In an experimental study, Roger *et al*. (2007) observed that imidacloprid seed treatment in high concentration exhibit translocation to flowers and reduced survivorship and after behavior of pink Lady bird beetle, coleomgilla maculate DeGee and green lacewing Chrysoperla carnea.

According to Mote *et al.* (1995) imidacloprid seed treatment in an experiment reduces the sucking pest populations below the economic thresh hold level up to 40 days after sowing. Several other researchers (Dandale *et al*. 2001; Murugan *et al*., 2003) reported that imidacloprid treatment on cotton seeds were found to be effective against leaf hoppers population up to 61 days after germination.

Thiram, the second active ingredient in insector T45, is a non – systemic fungicide, it is an organic sulphur fungicide classified under dithiocarbamate used to prevent crop damage (Isayama *et* al 2005). Thiram is applied to seeds prior to planting both by commercial seed treaters and on farm application. Approximately165, 000 pounds of Thiram are applied to 35,000 acres of Straw berries, apples and peaches annually (EFA, 2013). Approximately 1.3 billion pound of Thiram is used to treat 1.3 billion pounds of seed annually (EFA, 2013)

Thiram is considered to be moderately toxic via the inhalation route of exposure

(EFA, 2013).Seed treatments with fungicides are the most economical and easiest method to protect important seed and young vulnerable seedling (Isayama *et al*., 2005).Most of the commercially produces seed of maize (Zea *mays* L.) is almost universally treated with a fungicide prior to sale in order to protect the seed from fungi infection after planting (Kommedahl and windels, 1986). Seed born pathogens can be successfully controlled through the use of suitable seed treatment with corresponding increase in the number of seed that can germinate under normal conditions (EFA, 2013)

Thiram is an excellent protectant compound registered for a large number of important crops (Kommedahl and Windels, 1986)

Seed maize treatment with synthetic chemicals during storage is an effectively method of preserving the quality of farmer saved seed (FSS)

Synthetic chemicals, however, are subjected to user abused; they are quite expensive and toxic to human and animal health (Chapman and Harris, 1981).Synthetic chemical have extremely low shelf – life and resource poor farmers lack technical knowledge in the handling and application of these chemicals (Maloy, 1993)

Also broad spectrum synthetic chemicals such as imidacloprid could be harmful to both beneficial and target organisms (Maloy, 1993). The application of synthetic chemicals has not been satisfactory to many small scale resource poor farmers in most part of the developing countries because they are simply expensive and may be applied wrongly by the farmers (Neergaard, 1988)

CHAPTER THREE

MATERIALS AND METHODS

3.1 The study approaches used were:

i. Field survey and

ii. Laboratory experiment

The field survey was conducted at the end of the major cropping season in 2013-2014 for the purpose of identifying maize farmers and to document their maize production system, their perceptions on constraints and other related problems encounter in the study areas namely`; Ejura, Sekyedumase and Nkoranza all within the transitional zone in Ghana.

These communities (Towns/Villages) are all well known for maize production. The laboratory experiment assessed seed maize quality characteristics of the farmer-saved seed, prepared and used plant extracts for treatment, take physiological seed quality assessment

3.2 Field Survey: Assessment of Farmers Maize Production System, perception on constraints and other related problems encounter in the study area

A total of 100 maize farmers were randomly selected based on their experience in maize cultivation from towns and villages of Ejura, Sekyedumasi and Nkoranza Districts and were used for the study. Thirty five of the farmers were from Ejura and Nkoranza and thirty of them at Sekyedumasi.

The farmers were interviewed at the end of the major cropping season in 2013-2014 using structured questionnaires to document farmer's source(s) of seed maize used in planting, determine the post-harvest management practices of the farmers that adversely affect the seed maize quality as well as assess the present quality characteristics of the maize seeds planted by the respondents in the study areas. The villages and towns across the selected communities were chosen with the help of Agricultural extension officers of the Ministry of Food and Agriculture (MoFA).

Most of the respondents were organized in clusters within the selected communities. Each one of the respondents was interviewed in the local Asante Twi Language and their responses were recorded. A total of 100 maize farmers were interviewed, comprising of 11 females and 89 males. The questionnaires were administered by the researcher. The data obtained was analyzed and expressed in percentages using Statistical Package for the Social Scientist (SPSS) version 16.

3.2.1 Procedures for seed maize sample collection in the study areas

The maize varieties used for the experiment included Yellow maize, Abrotia, Abrohuma, Abeleehe and Obaatanpa. A total of 30kg seed lots were collected as a whole across the study areas.

Two kilograms primary samples of each of the five maize varieties were collected from each study area. The seed samples were collected per farmer interviewed after the seeds were harvested and stored. The cultural practices of the respondents across the study areas in respect of cultivation practices, crop maintenance, harvesting methods, processing methods, packaging, seed treatments were similar. The five deffierent seed maize obtained acrosse the selectd communities were labelled labeled and put into transparent polythene bags which were sealed off and transported to the laboratory at the Department of Soil and Plant Sciences of the Faculty of Agriculture, Kwame Nkrumah University of Science and Technology (KNUST) Kumasi, Ghana.

3.3 Assessment of the quality characteristics of farmer-saved seeds (Laboratory studies).

The farmer-saved maize seed quality Analysis was carried out under the seed purity test, seed moisture test, seed germination test, seed vigour test, insect damage assessment on seeds, seed health test and assessment of seeds for deformities.

3.3.1. Seed purity test

The seed lots samples of each of the five maize varieties obtained across the study areas were taken through seed purity test. The seed lots were separated into three categories according to the procedure of the International Seed Testing Association (ISTA) (2007) as:

.Pure seed lots

.Other varietal seeds

.Inert materials

The initial weights (20grams) of each of the five maize varieties sampled seed lots with other varieties seeds and inert materials were measured and the results recorded. The components were then separated into pure seed lots on one hand and varietal seeds with inert matter on the other hand and resultant components re-weighed. Data obtained were computed for each of the components and expressed in percentages relative to the weight of the samples that were tested for purity.

3.3.2. Seed moisture level determination

The seed samples of each the five varieties sourced from the respondents in the selected communities were used for seed moisture determination. Twenty (20) grams each of the five different varieties of maize seed lots from each farmer were weighed and put into envelops and sealed. The sealed envelopes containing the maize seed lots were placed in an oven at 70^{o}C till constant weight was achieved. Data obtained was expressed in percentages as against the initial weight of the seed lots twenty (20) grams before the oven drying process.

3.3.3. Maize seed germination test

Germination test involving each of the five maize seeds lots varieties obtained from each of the respondents in the studied communities was carried out using the method described by Daniel (1997). Petri-dishes measuring 9cm in diameter were used. The petri-dishes were lined with three layers of tissue papers each. The tissue papers were then moistened with 20ml of distilled water. Five seeds of maize were placed in each petri dish before moistening. Each variety of the maize seeds was replicated four times.

Germination count was done on the 3rd, 5th and 7th day after planting. Germination was considered to be completed when the roots of the developing seedlings radicals were prominent. Seedlings were classified into normal seedlings and abnormal seedlings and were expressed in percentages.

3.3.4 Seed Vigour Test

Each of the five varieties of the maize seed lots from one selected communities were tested for their speed of germination (vigour). The germination data obtained at the end of germination were used to estimate the rate of germination as the reprocical of the time taken of each variety of seed lots to reach maximum germination within seven days of incubation (Daniel, 2007). Seedlings length was measured with a ruler after the third and seventh day, they were then kept into envelops and dried in an oven at 70`C for 24 hours. The growth rates of the seedlings were estimated using the formulae by Daniel, IQ (1997) as

Follows: seedling growth= $\frac{dw_2 - dw_1}{T}$

Where;

t = the time difference

dW_2= seedling dry weight after seven days of culture and

dW_1 = seedling dry weight after three days of culture

3.3.5. Seed Health Test

Seed health test was carried out on each of the five varieties of maize seeds obtained from the study communities, for the purpose of finding out the seed borne fungal pathogens prevalent across the studied communities. Isolation and identification of the seed borne fungi were carried out according to standard test described by the International Seed Testing Association (ISTA). Samples of each of the five different varieties of the maize seeds were soaked separately in sodium hydroxide (NaOH) solution for 22-24 hours, they were than washed through a set of sieves and cleaned. They were transferred into an acetic acid solution glycerol mixture and subsequently stained. Mycelium was observed through a stereo microscope and fungal characteristics typical of each fungus were used to identify the incidence associated with each of the five different maize varieties. The results were recorded down. The test was carried out at the pathology laboratory at the Kwame Nkrumah University Science and Technology.

3.7.6. Insect Assessment Damage on the Seed Maize

Insect pest assessment damage on the seed maize of each of the five maize varieties obtained from the respondents in the study area was carried out. Samples of each of the five maize varieties were put into five trays each tray contained one variety of the seed lots. For each maize variety in a given tray two hundred samples of the seed lots were randomly fetched and carefully examined under a hand lens. Seed lots that were bored by insects were separated from those that were not damaged and the results obtained expressed in percentages.

3.3.7. Assessment of Deformed (Shriveled) Seeds

Two hundred randomly selected seeds, each from the five maize varieties were assessed for the purpose of determining the number of seed lots that were deformed (shriveled).The randomly fetched sampled seed lots were spread out in tray and closely examined through a hand lens and seeds that were found to be deformed were sorted out and separated from the rest of seed lots that were without deformities.

3.4. Preparation of Botanical Material

The botanical materials tested were bitter leaf (*Virnonia amygdalina)* and sweet potato leaf (*Ipomoea batatas).* The fresh leaves samples of the two plants made up of mixtures of older, succulent and tender leaves were collected from the University of Education Winneba, Ashanti Mampong Campus(Ghana) The plant samples were washed with clean running tap water to remove dust and soil particles. They were first heaped on a table measuring1 meter in height for the water to drain off and subsequently thinly spread out on a wooden bench one meter high to dry under room temperature for two weeks. Each of the botanicals was then milled separately into powder, using the laboratory miller and sieved with a sieve of 0.25mm × 1mm mesh sieve diameter to obtain a fine powder pore space. The powder obtained were sealed off in a transparent polythene bags and stored under room temperature until they were required for use.

Plate 1: Botanical materials milled and package at the pathology laboratory (KNUST)

3.5. Re-Packaging of Sampled Seed Maize

A total of six (6) kilograms of the seed lots of all the five maize seed varieties were repackaged.

Each of the five varieties of maize samples obtained from the respondents during the survey was re-packaged into high density poly bags measuring 13×14 cm^3.

On hundred grams of each of the five maize seed varieties was measured using the electronic digital scale and re-packaged into the high density poly bags.

3.6. Seed Treatment

The quantity of botanical leaf powders of the bitter leaf and sweet potato leaf were admixed with the seed maize samples worked out on a weight of powder/weight of seed maize, w/w basis. five grams of each botanical to 100grams of seed maize.The mixture of the botanicals with the seed lots in the high density poly bags were each thoroughly shaken for one minute and the content sealed off and those treated with synthetic chemical (Insector T45) and without chemical treatment were used as a comparative control for the botanical treatments. The synthetic chemical insector T45 contained imidachlopride 350kg +Thiram 100k/kg: DS, and was applied as specified by the manufacturer. These synthetic chemicals were applied at the recommended rate specified by the manufacturer.

A total of four (4) treatments each replicated three (3) times were arranged in a Completely Randomized Design (CRD) as:

I. Seed maize treated with chemicals.

II. Seed maize without botanical or synthetic chemical treatment. They were kept on a wooden bench measuring 1 meter high.

3.7. Storage of Treated Seeds

All the treated seeds were stored at the Soil and Crop Science Department Laboratory of the Faculty of Agriculture, Kwame University of Science and Technology (KNUST) Kumasi, Ghana under ambient temperature and prevailing relative humidity of 17-

28`C—38-69·/.RH The treatments were not tempered with throughout the storage period of four (4) months.

3.8. Evaluation of seed quality characteristics after seed treatment and storage for 4months (laboratory studies)

At the end of the storage period of four months, laboratory experiment was carried out to evaluate the maize seed lots quality characteristics following the same laboratory procedures for assessing the quality characteristics of the seeds before the start of the investigation as described earlier in section 3.3

CHAPTER FOUR

RESULTS

4.0 Survey: Assessment of farmers' maize production systems, perceptions on constraints and other related problems encountered in the study areas

4.1 Biographical data of the maize farmers in the selected communities

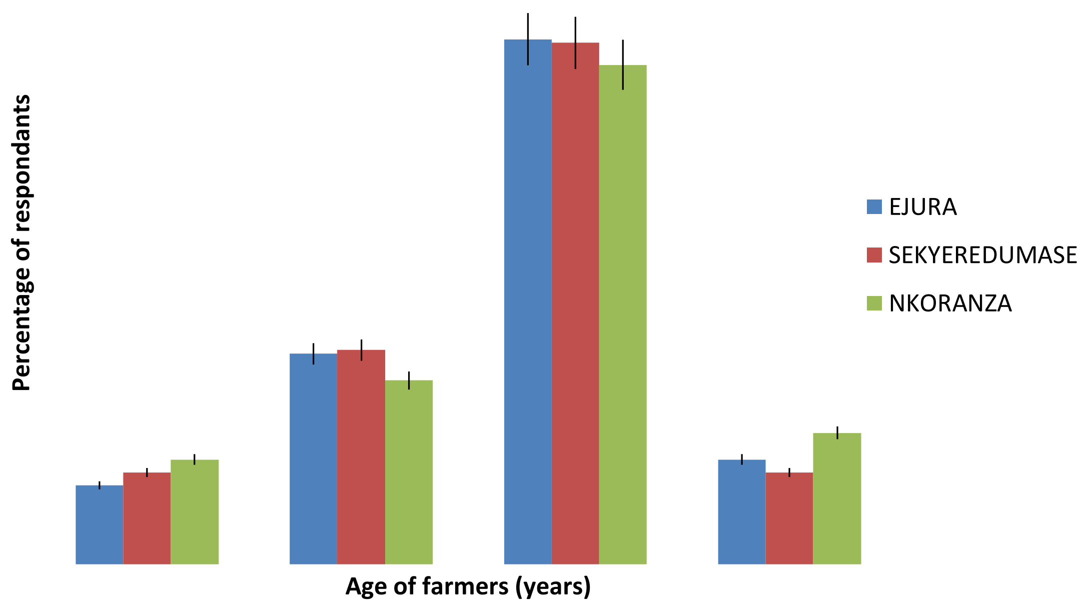

Fig.4.1. Age range of farmers in the selected communities

All the three communities had majority of it farmers between the age range of 40-50 years. Ejura had 57.1 %, Sekyeredumase 56.7 % and Nkoranza 54.3 %. Those between

30-39 were 23.3%, 22.9% and 20% for Sekyereduase, Ejura and Nkoranza respectively. On the contrarly more farmers were above 50 years at Nkoranza (14.3%), Ejura (11.4%) and 10% from Sekyeredumase. Those between 18-29 were 11.4% for Nkoranza, 10% for Sekyeredumase and 8.6% from Ejura (Fig. 4.1).

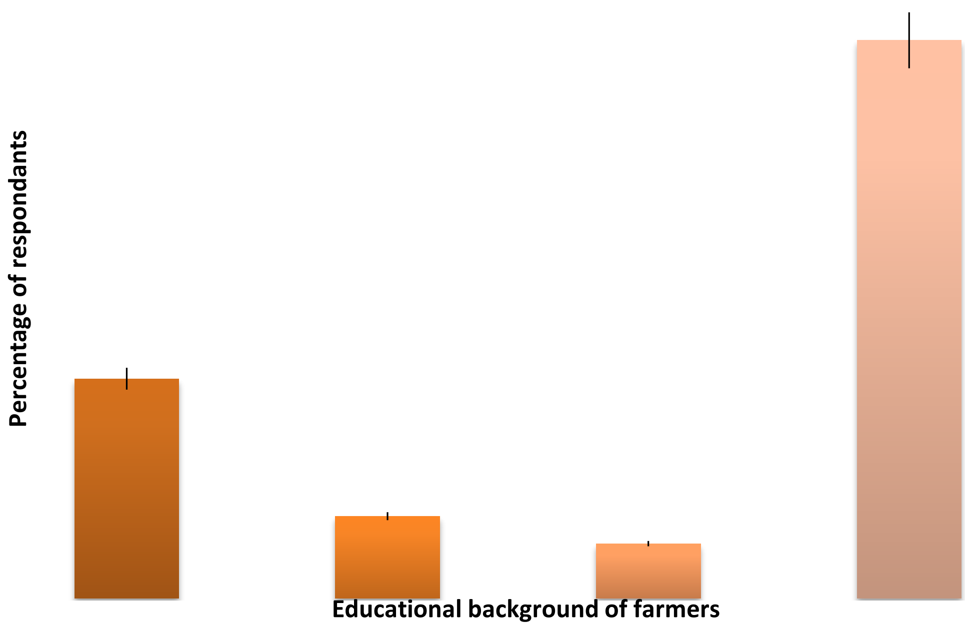

Fig.4.2 Educational background of farmers

About sixty-one percent (61%) of the farmers had no formal education with only six percent (6%) of them being educated to the tertiary level. The remaining had some formal education up to SHS or form four nine percent (9%) and primary school education twenty four percent (24%).

Fig 4.3 Sources of seed maize

Fifty- three percent (53%) of the farmers were use their own saved seeds, twenty four (24 %) of them were buy from the local market, eleven percent (11%) had their source of

Seeds from friends and neighbours whiles 8 and 4 % of the farmers respectively obtained their seeds from Agrochemical stores and NGO's (Fig 4.3).

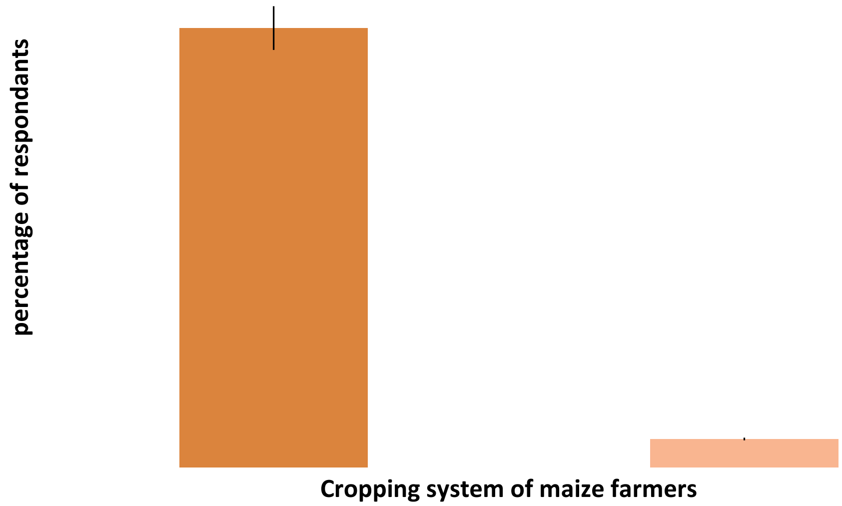

Fig 4.4. Cropping system of maize farmers

Ninety-four percent (94%) of the farmers were into sole maize cultivation whiles 6% of the farmers intercrop maize with other crops such cowpea (Fig 4.4)

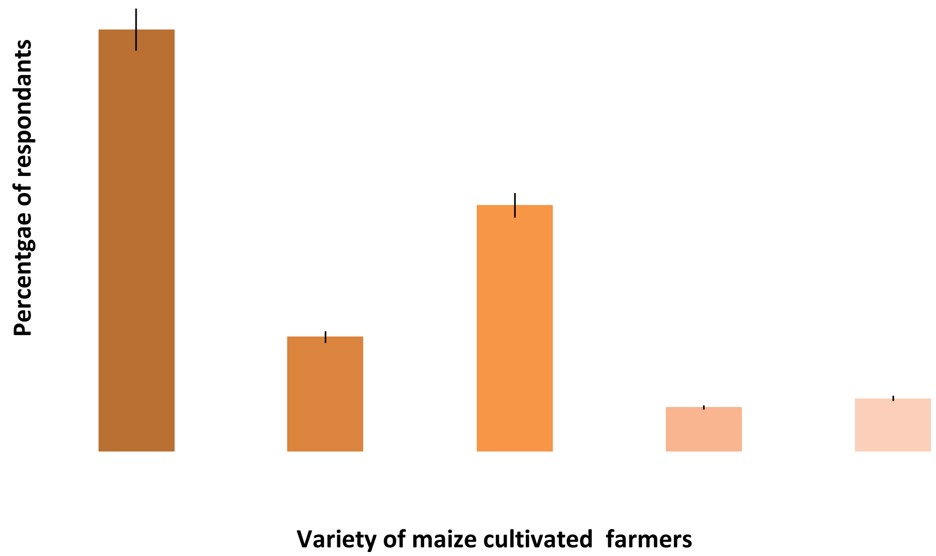

Fig. 4.5 Variety of maize cultivated by farmers

Fig. 4.5 shows that Abrohuma was the most cultivated maize by the farmers with forty eight percent (48%) of the farmers planting that variety, followed by Obaatanpa twenty-eight percent (28%), Abrotia thirteen percent (13%), yellow maize six percent (6%) and Abeleehe was being the least cultivated variety (5%).

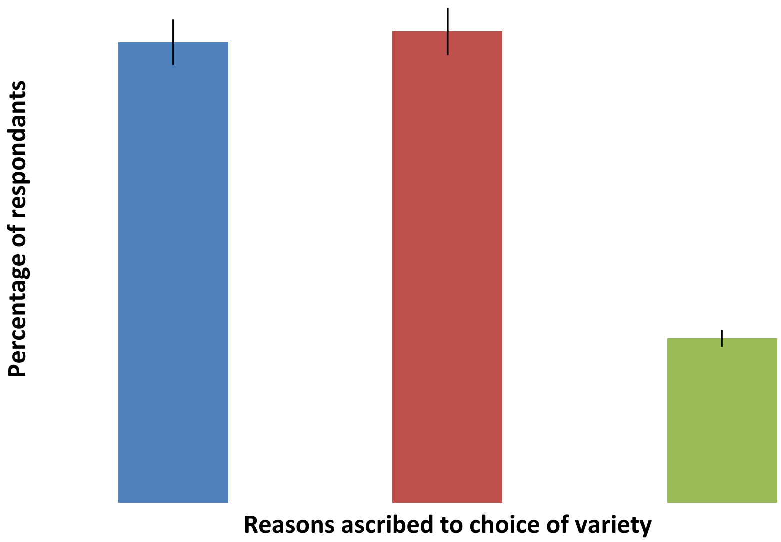

Fig. 4.6 Reasons ascribed to choice of variety

Reasons ascribed to choice of variety was that forty three percent (43%) of the farmers claimed it was marketable, forty two percent (42%) said it was early maturing whiles fifteen percent (15%) of the farmers claimed it was both early maturing and marketable (FIG.4.6)

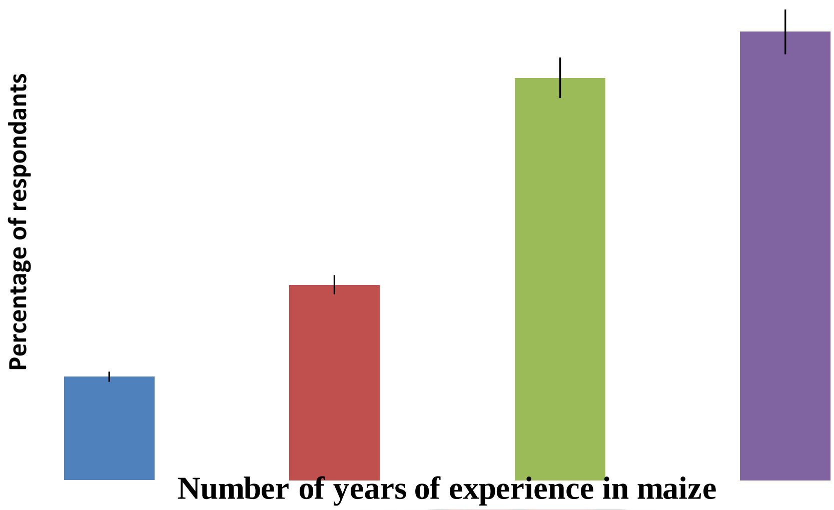

Fig.4.7 Number of years in maize cultivation

About thirty-nine (39%) of the farmers have being cultivating maize for more than 10 years. Thirty-five percent (35%) of the farmers had been cultivating maize for 7-9 years, 17% of them for 4-6 years while only 9% have been in the business for 1-3 years (Fig.4.7).

The results of Correlation analysis between age of farmers and number of years of experience indicated no correlation between the parameters. This implies that a farmer may be above fifty years and may not be experience in the maize cultivation and the vice versa (appendix B1)

Fig.4.8 Farm size of farmers

Fifty-three percent (53%) of the farmers have their farm size ranging between 2.5 and 3.5 ha, nineteen percent (19%) each of the farmers had their farm size between 1.5 and 2ha and above 4 ha respectively. Only nine percent 9% of the farmers have their farm size ranging between 0-1ha (fig.4.8).

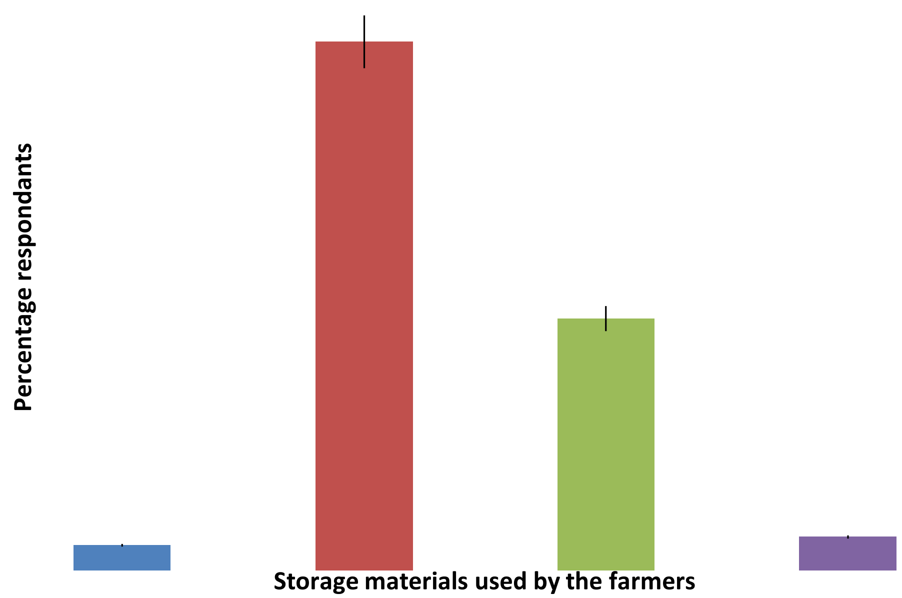

Fig. 4.9 Storage materials use by farmers

Jute bag was the most common storage container used (63%). This was followed by the use of Silo/shed (30%). Earthenware and poly bags were the least storage containers used by the farmers representing 4 and 3 % respectively (Fig.4.9).

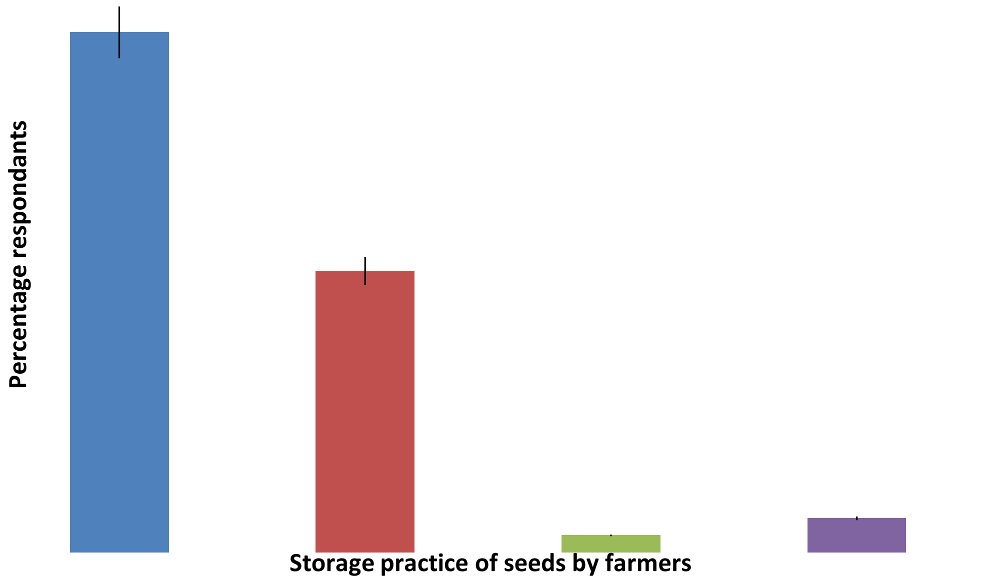

Fig.4.10. Storage practice adopted by farmers

In terms of storage practice adopted by the farmers, store rooms method were most frequently used representing sixty-one (61%), thirty three percent (33%) of the farmers used shed/silos for storage. Only four percent (4%) of the farmers use the open space and two percent (2%) of the farmers store their maize in a cold room.

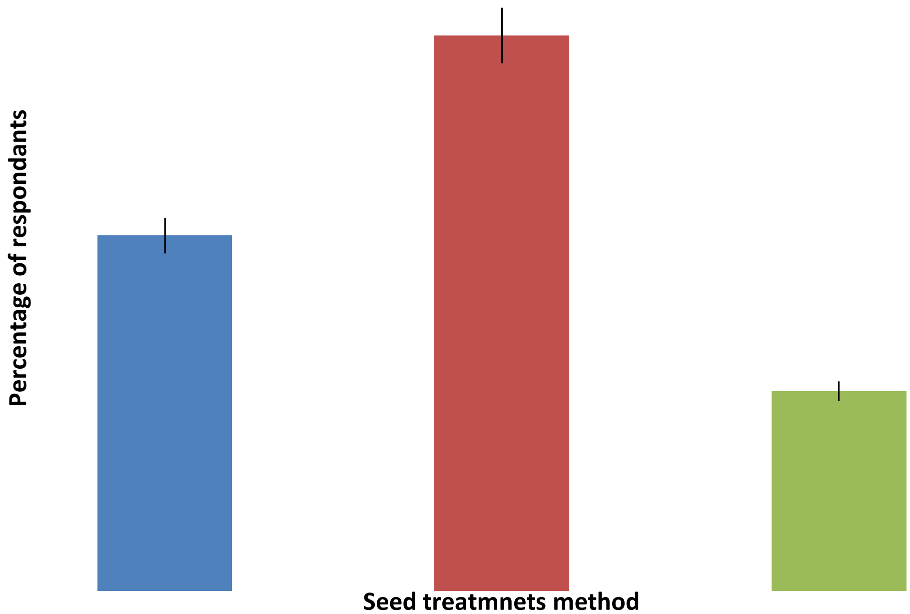

Fig.4.11. Seed treatment method, use by the farmers.

The use of synthetic chemical was the most common method of seed treatment by the farmers, this was followed by the use of plant extracts such as garlic (50%) and 32 % respectively. About 18% of the farmers were not treating their seed maize (fig.4.11).

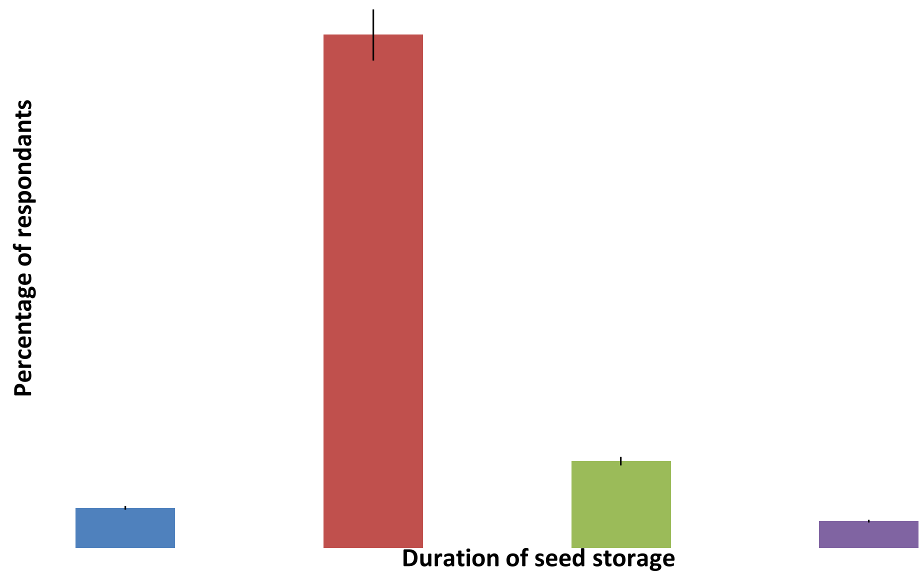

Fig.4.12. Duration of seed storage by the farmers

Similarly seventy-seven percent (77%) of the farmers stored their seed maize for a period of 6-7 months, 13% of them for a period of 9-10 months, farmers who stored their seed for 3-5 months were 6% and only 4% of the farmers stored their seeds up to a year (Fig.4.12)

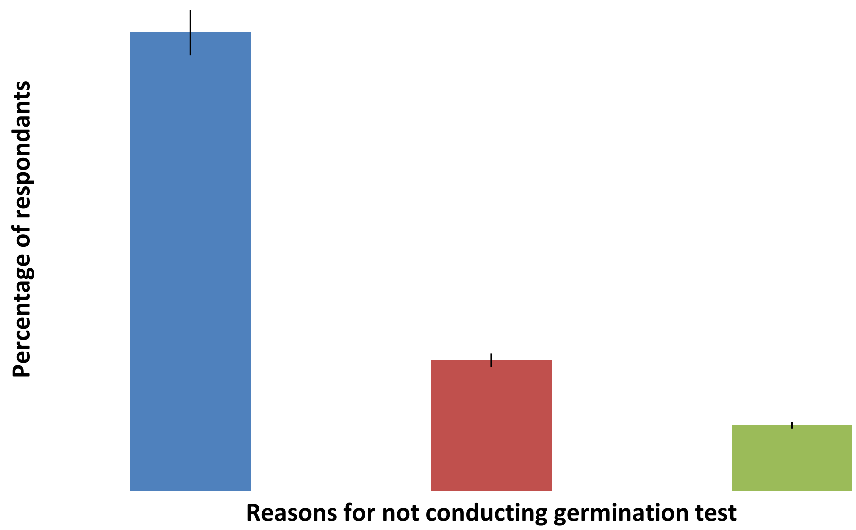

Fig.4.13 Reasons for not conducting germination test of seeds

None of the farmers conducted germination test on the seed use and reasons ascribed were that they had faith in their seed (20% of the farmers) and inadequate technical knowhow (10%). The majority of the farmers (70%) claimed they have no reason for not conducting germination test (Fig.4.13)

4.1 Effects of variety on maize seeds quality characteristics before storage

4.1.1 Effects of variety on deformed seeds (%) before storage

There were significant differences among treatments for percent deformed seeds before storage (Table 4.1). The highest percentage (27.67%) of deformed seeds was produced by Abrohuma. Yellow Maize variety produced the lowest percentage (9.67%) of deformed seeds amongst all the treatments. Percentage of deformed seeds of Abrohuma was significantly different from Yellow Maize, Abrotia and Obaatanpa but was significantly similar to Abeleehe (Table 4.1).

Table 4.1: Effects of variety on deformed seeds before storage

	Deformed seeds (%)
Varieties	**Deformed seeds (%)**
Yellow Maize	9.67
Abrohuma	27.67
Abrotia	23.33
Abeleehe	27.00
Obaatanpa	13.67
HSD (0.01)	3.720

4.1.2 Effects of variety on moisture level (%) of maize seeds before storage.

There were no significant differences among treatments for percent moisture level before storage (Table 4.2). However, Abrotia produced the highest percentage (15.38%) and Abrohuma produced the lowest percentage (14.80%) amongst the treatments (Table 4.2).

Table 4.2: Effects of variety on moisture level before storage

Varieties	Moisture level (%)
Yellow Maize	15.26
Abrohuma	14.80
Abrotia	15.38
Abeleehe	14.95
Obaatanpa	14.90
HSD (0.01)	1.646

4.1.3 Effects of variety on germination percentage (%) of maize seeds before storage

There were no significant differences among treatments for percent seed germination (Table 4.3).

However, Abrotia and Abeleehe produced the highest percentage (100.00%) whiles Obaatanpa produced the lowest percentage (98.67%) amongst all the treatments (Table 4.3).

Table 4.3: Effects of variety on Germination Percentage before storage

Varieties	Germination Percent (%)
Yellow Maize	99.67
Abrohuma	99.33
Abrotia	100.00
Abeleehe	100.00
Obaatanpa	98.67
HSD (0.01)	1.637

4.1.4 Effects of variety on disease incidence (%) before storage

There were no significant differences among treatments for percent disease incidence (Table 4.4). However, Obaatanpa produced the highest percentage (37.37%) and Abrohuma produced the lowest percentage (20.63%) amongst all the treatments (Table 4.4).

Table 4.4: Effects of variety on disease incidence before storage

Varieties	Disease incidence (%)
Yellow Maize	25.63
Abrohuma	20.63
Abrotia	28.50
Abeleehe	32.50
Obaatanpa	37.37
HSD (0.01)	21.467

4.1.5 Effects of variety on Pest damage (%) before storage

There were significant differences among treatments for percent pest damage (Table 4.5).

The highest percentage (27.33%) of pest damage was produced by both Abrohuma and Abeleehe. Yellow maize produced the lowest percentage (8.67%) of pest damage but was not significantly different from Obaatanpa. However, Abrotia was significantly different from all the other treatments (Table 4.5).

Table 4.5: Effects of variety on pest damage before storage

Varieties	Pest damage (%)
Yellow Maize	8.67
Abrohuma	27.33
Abrotia	22.00
Abeleehe	27.33
Obaatanpa	12.33
HSD (0.01)	3.720

4.1.6 Effects of variety on Seed purity (%) before storage

There were significant differences among treatments for percent seed purity (Table 4.6).

The highest percentage (60.43%) of seed purity was produced by Abrotia and Abrohuma produced the lowest percentage (50.27%) of seed purity.

However, Obaatanpa and Abeleehe were not different significantly from each other and were not also significantly different from Yellow Maize, Abrohuma and Abrotia but both Yellow Maize and Abrohuma were significantly different from Abrotia (Table 4.6).

Table 4.6: Effects of variety on seed purity before storage

Varieties	Seed purity (%)
Yellow Maize	52.87
Abrohuma	50.27
Abrotia	60.43
Abeleehe	56.27
Obaatanpa	54.27
HSD (0.01)	6.920

4.1.7 Effects of variety on Seed vigour (%) before storage

There were no significant differences among treatments for seed vigour (Table 4.**7**).

The highest percentage (73.33%) of seed vigour was produced by Yellow Maize and the lowest percentage (53.33%) of seed vigour was produced by Obaatanpa (Table 4.**7**).

Table 4.7: Effects of variety on seed vigour before storage

Varieties	Seed vigour (%)
Yellow Maize	73.33
Abrohuma	70.00
Abrotia	66.67
Abeleehe	70.00
Obaatanpa	53.33
HSD (0.01)	41.725

4.2 Effects of variety and insecticides on maize seeds after storage

4.2.1 Effects of variety on germination percentage (%) after storage

There were no significant differences among treatments for percent germination (Table 4.8).

The highest percentage (89.67%) of germination was produced by Abrotia and the lowest percentage (85.25%) of germination was produced by Obaatanpa (Table 4.8).

Table 4.8: Effects of variety on Germination Percentage after storage

Varieties	Germination percentage (%)
Yellow Maize	86.58
Abrohuma	86.50
Abrotia	89.67
Abeleehe	88.33
Obaatanpa	85.25
HSD (0.01)	24.995

4.2.2 Effects of insecticides on germination percentage (%) after storage

There were no significant differences among treatments for percent germination (Table 4.9).

The highest percentage (94.27%) of germination was produced by Insector T45 (Synthetic) and the lowest percentage (82.73%) of germination was produced by Bitter leaf extract (Table 4.9).

Table 4.9: Effects of insecticides on germination percentage after storage

Insecticides	Germination percentage (%)
Insector T45 (Synthetic)	94.27
Bitter leaf extract	82.73
Sweet potato leaf extract	86.93
Untreated control	85.13
HSD (0.01)	21.312

4.2.3 Effects of variety and insecticides on germination percentage (%) after storage

There were no significant varieties x insecticides interactions for percent germination (Table 4.10). However, yellow maize treated with Insector T45 insecticide produced the highest percentage (96.33%) of germination and yellow maize treated with sweet potato leaf extract produced the lowest percentage (80.00%) of germination (Table 4.10).

Table 4.10: Effects of variety and insecticides on germination percentage after storage

	Germination percentage (%)				
Variety	Insecticide				Mean
	Insector T45 (Synthetic)	Bitter leaf extract	Sweet potato leaf extract	Untreated control	
Yellow Maize	96.33	85.00	80.00	85.00	86.583
Abrohuma	94.67	84.33	86.33	80.67	86.500
Abrotia	93.00	82.33	95.00	88.33	89.667
Abeleehe	94.00	88.33	89.67	88.33	88.333
Obaatanpa	93.33	80.67	83.67	83.33	85.250
Mean	94.267	82.733	86.933	85.133	
HSD (0.01): Variety =24.995; Insecticide =21.312; Variety x Insecticide =62.640.					

4.2.4 Effects of variety on moisture content (%) after storage

There were no significant differences among treatments for percent moisture content (Table 4.10).The highest percentage (13.64%) of moisture content was produced by Abeleehe and the lowest percentage (12.91%) of moisture content was produced by Obaatanpa (Table 4.11).

Table 4.11: Effects of variety on moisture content after storage

Varieties	Moisture content (%)
Yellow Maize	13.00
Abrohuma	13.48
Abrotia	13.59
Abeleehe	13.64
Obaatanpa	12.91
HSD (0.01)	1.221

4.2.5 Effects of Insecticides on moisture content (%) of maize seeds after storage

There were no significant differences among treatments for percent moisture content (Table 4.12).

The highest percentage (13.55%) of moisture content was produced by sweet potato leaf extract and the lowest percentage (13.02%) of moisture content was produced by Insector T45 (Synthetic) (Table 4.12).

Table 4.12: Effects of insecticides on moisture content of maize seeds after storage

Insecticides	Moisture content (%)
Insector T45 (Synthetic)	13.02
Bitter leaf extract	13.22
Sweet potato leaf extract	13.55
Untreated control	13.51
HSD (0.01)	1.041

4.2.6 Effects of variety and insecticides on moisture content (%) of maize seeds after storage

There were no significant varieties x insecticides interactions for percent moisture content (Table 4.13). However, the untreated Abrotia (control) produced the highest percentage (13.98%) of moisture content and yellow maize treated with Insector T45 (Synthetic) produced the lowest percentage (12.47%) of moisture content (Table 4.13).

Table 4.13: Effects of variety and insecticides on moisture content after storage

Moisture content percentage (%)					
Variety	**Insecticide**				
	Insector T45 (Synthetic)	Bitter leaf extract	Sweet potato leaf extract	Untreated control	Mean
Yellow Maize	12.47	12.92	13.40	13.21	13.001
Abrohuma	13.24	13.39	13.57	13.73	13.483
Abrotia	13.24	13.36	13.78	13.98	13.588
Abeleehe	13.38	13.49	13.91	13.78	13.642
Obaatanpa	12.79	12.91	13.06	12.87	12.906
Mean	13.023	13.215	13.545	13.514	

HSD (0.01): Variety =1.2212; Insecticide =1.0412; Variety x Insecticide =3.0604.

4.2.7 Effects of variety on seed vigour (%) of maize seeds after storage

There were no significant differences among treatments for percent seed vigour (Table 4.14).

The highest percentage (67.08%) of seed vigour was produced by yellow maize and the lowest percentage (52.92%) of seed vigour was produced by Obaatanpa (Table 4.14).

Table 4.14: Effects of variety on seed vigour after storage

Varieties	Seed vigour (%)
Yellow Maize	67.08
Abrohuma	64.83
Abrotia	58.00
Abeleehe	62.33
Obaatanpa	52.92
HSD (0.01)	32.005

4.2.8 Effects of insecticides on seed vigour (%) of maize seeds after storage

There were no significant differences among treatments for percent seed vigour (Table 4.15).

The highest percentage (69.47%) of seed vigour was produced by treating maize seeds with Insector T45 (Synthetic) and the lowest percentage (56.73%) of seed vigour was produced by untreated control (Table 4.15).

Table 4.15: Effects of insecticides on seed vigour after storage

Insecticides	Seed vigour (%)
Insector T45 (Synthetic)	69.47
Bitter leaf extract	58.40
Sweet potato leaf extract	59.53
Untreated control	56.73
HSD (0.01)	27.289

4.2.9 Effects of variety and insecticides on seed vigour (%) of maize seeds after storage

There were no significant varieties x insecticides interactions for percent seed vigour (Table 4.16). However, yellow maize treated with Insector T45 (Synthetic) produced the highest percentage (76.67%) of seed vigour and obaatanpa treated with bitter leaf extract produced the lowest percentage (44.33%) of seed vigour (Table 4.16).

Table 4.16: Effects of variety and insecticides on seed vigour after storage

Seed vigour (%)					
Variety	**Insecticide**				Mean
	Insector T45 (Synthetic)	Bitter leaf extract	Sweet potato leaf extract	Untreated control	
Yellow Maize	76.67	63.00	73.33	55.33	67.083
Abrohuma	73.00	59.67	67.00	59.67	64.833
Abrotia	68.67	59.00	49.67	54.67	58.000
Abeleehe	72.67	66.00	55.00	55.67	62.333
Obaatanpa	56.33	44.33	52.67	58.33	52.917
Mean	69.467	58.400	59.533	56.733	

HSD (0.01): Variety =32.005; Insecticide =27.289; Variety x Insecticide =80.208.

4.2.10 Effects of variety on bored seeds (%) after storage

There were no significant differences among treatments for percent bored seed (Table 4.17).

The highest percentage (26.00%) of bored seed was produced by Abrohuma and the lowest

Percentage (18.67%) of bored seed was produced by Abeleehe (Table 4.17).

Table 4.17: Effects of variety on bored seeds after storage

Varieties	Bored seeds (%)
Yellow Maize	22.50
Abrohuma	26.00
Abrotia	20.33
Abeleehe	18.67
Obaatanpa	19.50
HSD (0.01)	41.172

4.2.11 Effects of insecticides on bored seeds (%) after storage

There were significant differences among treatments for percent bored seed (Table 4.18).

The highest percentage (50.50%) of bored seed was produced by untreated control and the lowest percentage (3.50%) of bored seed was produced by bitter leaf extract (Table 4.18).

However, Insector T45 (Synthetic) and bitter leaf extract were significantly similar to sweet potato leaf extract but significantly different from untreated control (Table 4.18).

Table 4.18: Effects of insecticides on bored seeds after storage

Insecticides	Bored seeds (%)
Insector T45 (Synthetic)	7.77
Bitter leaf extract	3.50
Sweet potato leaf extract	23.83
Untreated control	50.50
HSD (0.01)	35.105

4.2.12 Effects of variety and insecticides on bored seeds (%) of maize seeds after storage

There were no significant varieties x insecticides interactions for percent bored seed (Table 4.19). However, Abrohuma under untreated control produced the highest percentage (58.50%) of bored seed and Obaatanpatreated with Insector T45, Obaatanpa treated with bitter leaf extract, Abeleehe treated with bitter leaf extract produced the lowest percentage (2.50%) of bored seed (Table 4.19).

Table 4.19: Effects of variety and insecticides on bored seeds after storage

	Bored seed (%)				
Variety	**Insecticide**				Mean
	Insector T45 (Synthetic)	Bitter leaf extract	Sweet potato leaf extract	Untreated control	
Yellow Maize	25.83	2.83	3.50	57.83	22.500
Abrohuma	3.50	4.50	37.50	58.50	26.000
Abrotia	3.17	5.17	28.50	44.50	20.333
Abeleehe	3.83	2.50	24.17	44.17	18.667
Obaatanpa	2.50	2.50	25.50	47.50	19.500
Mean	7.767	3.500	23.833	50.500	

HSD (0.01): Variety =41.172; Insecticide =35.105; Variety x Insecticide =103.18.

4.3 Microbial infection of maize

A total of three fungal species were identified on the maize in storage. These were *Colletotrichum granicola, Colletotrichum gloeosporiods and Penicillium spp*.

4.3.1 Effects of variety on *Colletotrichum granicola* (%) identified on maize seeds after storage

There were no significant differences among treatments for percent *Colletotrichum granicola* (Table 4.20).

The highest percentage (11.11%) of *Colletotrichum granicola*was produced by yellow maize and the lowest Percentage (4.44%) of *Colletotrichum granicola*was produced by Abrohuma (Table 4.20).

Table 4.20: Effects of variety on *Colletotrichum granicola* identified after storage

Varieties	*Colletotrichum granicola* (%)
Yellow Maize	11.11
Abrohuma	4.44
Abrotia	8.89
Abeleehe	8.89
Obaatanpa	5.55
HSD (0.01)	16.279

4.3.2 Effects of insecticides on *Colletotrichum granicola* (%) identified on maize seeds after storage

There were significant differences among treatments for percent *Colletotrichum granicola*(Table 4.21).

The highest percentage (18.67%) of *Colletotrichum granicola* was produced by untreated control and the lowest percentage (4.00%) of *Colletotrichum granicola*was produced by Insector T45 and sweet potato leaf extract (Table 4.21).

However, Insector T45 (Synthetic), bitter leaf extract and sweet potato leaf extract were significantly similar but significantly different from untreated control (Table 4.21).

Table 4.21: Effects of insecticides on *Colletotrichum granicola* identified after storage

Insecticides	Percentage *Colletotrichum granicola*
Insector T45 (Synthetic)	4.00
Bitter leaf extract	4.41
Sweet potato leaf extract	4.00
Untreated control	18.67
HSD (0.01)	13.88

4.3.3 Effects of variety and insecticides on *Colletotrichum granicola* (%) identified on maize seeds after storage

There were no significant varieties x insecticides interactions for percent *Colletotrichum granicola*(Table 4.22). However, yellow maize under untreated control produced the highest percentage (24.44%) of *Colletotrichum granicola* and Abrohuma treated with Insector T 45, Obaatanpa treated with Insector T45, Abrohuma treated with bitter leaf extract, Obaatanpa treated with Bitter leaf extract, Abrohuma treated with Sweet potato leaf extract and Obaatanpa treated with Sweet potato leaf extract all produced the lowest (2.22%) of *Colletotrichum granicola* (Table 4.22).

Table 4.22: Effects of variety and insecticides on *Colletotrichum granicola* after storage

Percentage *Colletotrichum granicola*					
Variety	**Insecticide**				Mean
	Insector T45 (Synthetic)	Bitter leaf extract	Sweet potato leaf extract	Untreated control	
Yellow Maize	6.66	6.66	6.66	24.44	11.108
Abrohuma	2.22	2.22	2.22	11.11	4.443
Abrotia	4.44	6.66	4.44	20.00	8.886
Abeleehe	4.44	4.44	4.44	22.22	8.886
Obaatanpa	2.22	2.22	2.22	15.56	11.108
Mean	3.997	4.441	3.997	18.667	

HSD (0.01): Variety =16.279; Insecticide =13.880; Variety x Insecticide =40.797.

4.3.4 Effects of variety on percentage of Colletotrichum gloeosporiods identified on maize seeds after storage

There were no significant differences among treatments for percent *Colletotrichum gloeosporiods* (Table 4.23).

The highest percentage (11.11%) of *Colletotrichum gloeosporiods* was produced by Abeleehe and the lowest Percentage (0.00%) of *Colletotrichum gloeosporiods* was produced by Obaatanpa (Table 4.23).

Table 4.23: Effects of variety on *Colletotrichum gloesporoids* identified after storage

Varieties	***Percentage Colletotrichum gloesporoids***
Yellow Maize	10.00
Abrohuma	5.55
Abrotia	5.55
Abeleehe	11.11
Obaatanpa	0.00
HSD (0.01)	14.53

4.3.5 Effects of insecticides on percentage of *Colletotrichum gloesporoids*(%) identified on maize seeds after storage

There were no significant differences among treatments for percent *Colletotrichum gloesporoids* (Table 4.24).

The highest percentage (14.22%) of *Colletotrichum gloesporoids* was produced by untreated control and the lowest percentage (2.66%) of *Colletotrichum gloesporoids* was produced by Insector T45 (Synthetic) (Table 4.24).

Table 4.24: Effects of insecticides on *Colletotrichum gloesporoids*identified after storage

Insecticides	**P*ercentage Colletotrichum gloesporoids*)**
Insector T45 (Synthetic)	2.66
Bitter leaf extract	4.00
Sweet potato leaf extract	4.44
Untreated control	14.22
HSD (0.01)	12.39

4.3.6 Effects of variety and insecticides of *Colletotrichum gloesporoids*(%) identified on maize seeds after storage

There were no significant varieties x insecticides interactions for percent *Colletotrichum gloesporoids*(Table 4.25). However, yellow maize under untreated control produced the highest percentage (26.67%) of *Colletotrichum gloesporoids* and Obaatanpa under Insector T45 (Synthetic), Bitter leaf extract, Sweet potato leaf extract and untreated control produced the lowest percentage (0.00%) of *Colletotrichum gloesporoids* (Table 4.25).

Table 4.25: Effects of variety and insecticides on *Colletotrichum gloesporoids* after storage

Percentage *Colletotrichum gloesporoids*)					
Variety	**Insecticide**				Mean
	Insector T45 (Synthetic)	Bitter leaf extract	Sweet potato leaf extract	Untreated control	
Yellow Maize	4.44	4.44	4.44	26.67	9.997
Abrohuma	2.22	2.22	4.44	11.11	5.554
Abrotia	2.22	4.44	4.44	11.11	5.554
Abeleehe	4.44	8.89	8.89	22.22	11.108
Obaatanpa	0.00	0.00	0.00	0.00	0.000
Mean	2.664	3.998	4.443	14.221	

HSD (0.01): Variety =14.529; Insecticide =12.388; Variety x Insecticide =36.411.

4.3.7 Effects of variety on percentage of *Penicillium spp* identified on maize seeds after storage

There were no significant differences among treatments for percent *Penicillium Spp*(Table 4.26).

The highest percentage (18.89%) of *Penicillium Spp*was produced by yellow maize and the lowest Percentage (5.56%) of *Penicillium Spp*was produced by Abrotia (Table 4.26)

Table 4.26: Effects of variety on *Penicillium Spp* identified after storage

Varieties	Percentage *Penicillium spp*
Yellow Maize	18.89
Abrohuma	17.77
Abrotia	5.56
Abeleehe	12.22
Obaatanpa	12.78
HSD (0.01)	15.766

4.3.8 Effects of insecticides on percentage of *Penicillium spp* (%) identified on maize seeds after storage

There were significant differences among treatments for percent *Penicillium Spp*(Table 4.27).

The highest percentage (30.22%) of *Penicillium Spp*was produced by untreated control and the lowest percentage (4.89%) of *Penicillium Spp*was produced by Insector T45 (Synthetic) (Table 4.27).

However, Insector T45 (Synthetic), Bitter leaf extract and Sweet potato leaf extract were significantly similar but significantly different from untreated control (Table 4.27).

Table 4.27: Effects of insecticides on *Penicillium Spp* identified after storage

Insecticides	***Percentage Penicillium Spp***
Insector T45 (Synthetic)	4.885
Bitter leaf extract	9.331
Sweet potato leaf extract	9.331
Untreated control	30.223
HSD (0.01)	13.443

4.3.9 Effects of variety and insecticides on percentage of *Penicillium Spp* (%) identified on maize seeds after storage

There were significant varieties x insecticides interactions for percent *Penicillium Spp*(Table 4.28). Yellow maize under untreated control produced the highest percentage (42.22%) of *Penicillium Spp*and Abrotia under Insector T45 (Synthetic) produced the lowest percentage (0.00%) of *Penicillium Spp*(Table 4.28).

However, Abrotia under both Insector T45 (Synthetic) and Sweet potato leaf extract were significantly different from Yellow Maize under untreated control but were also significantly similar to all the other interactions (Table 4.28).

Table 4.28: Effects of variety and insecticides on *Penicillium Spp* after storage

Percentage *Penicillium Spp*					
Variety	**Insecticide**				Mean
	Insector T45 (Synthetic)	Bitter leaf extract	Sweet potato leaf extract	Untreated control	
Yellow Maize	6.66	13.33	13.33	42.22	18.89
Abrohuma	6.66	13.33	13.33	37.77	17.77
Abrotia	0.00	4.44	2.22	15.56	5.55
Abeleehe	4.44	6.66	8.89	28.89	12.22
Obaatanpa	6.66	8.89	8.89	26.67	12.78
Mean	4.885	9.331	9.331	30.223	

HSD (0.01): Variety =15.766; Insecticide =13.443; Variety x Insecticide =39.512.

CHAPTER FIVE

5.0. DISCUSSION

5.1 Socio- personal profile of respondants

All the 100 farmers who were interviewed across the study areas were maize farmers. About 56% of them were the Youth involved in maize production in the selected communities. It was revealed from the research that most of the Youth engaged in maize production in the study areas within the transitional zone of Ghana were migrant labour from the Northern parts of the country to the transitional zone in search of jobs and educational opportunities. This has agreed with the reports made by Ghana statistical service (2002) that every year, a large proportion of adult, and sometimes children population travel hundreds of Kilometers from the Northern sector of the country to the Southern sector of Ghana to work as seasonal farm labourers because there are few employment opportunities in their home villages especially during the dry season (November to May)

The improved transportation network coupled with the abundance and readily available fertile arable lands in the transitional zone of Ghana were the reasons behind the exodus of the Youth from the Northern sector to the Southern sector for the purpose of large scale commercial production of food crops (GSS, 2002)

Maize is one such commodity capable of achieving food security in Ghana and all efforts needed to motivate the youth to take up maize production must be encouraged for they are the most energetic portion of the labour force capable of increasing maize productivity. Providing the youth with adequate resources required to venture into the production of maize will not only attract them to take up the business but will also help to erase the erroneous impression held by many people in Ghana that crop production is reserved for the poor in society.

It was observed that, 61% of the respondents were without formal education. The relatively large proportion of the respondents without formal education has several implications in the handling and application of agricultural chemicals as reported by Bull (1989). Educational enhances the managerial and technical skills of farmers (Battese and Coelli, 1995). Education is hypothesized to increase the farmers' ability to utilize existing technologies to attain higher efficiency level (Owour and Shem, 2009). However, another school of thought has it that educational level is negativity correlated to technical efficiency of farmers, much especially in developing countries where technical skills in agricultural activities are more influenced by ''hands on'' modern agricultural methods than just formal schooling (Owour and Shem,2009)

Technical inefficiency in agriculture tends to increase after five (5) years of schooling according to Kibaara (2005) because attainment of high education dampens the desire for farming in favour of salaried work and eventually affects the availability of labour for farm production thereby lowering efficiency. Generally, access to better education will enable farmers to manage resources better in order to sustain the environment and produce at optimum levels (Kibaara, 2005)

Fifty three percent (53%) of the respondents reported that they obtained their seed maize for planting through the informal channels mainly from their previous harvest and this is consistent with earlier findings by Almekinders *et al*. (1994) that 90% of crops grown by farmers in the developing countries are planted out of farmers varieties and farmer-saved seeds (FSS)

The use of low quality farmer –saved seeds have been mainly accused as the reason why farmers in sub –Saharan Africa are unable to cope with production because such seeds, according to Tagne *et al*.(2008) ,have been rejected by plant breeders and researchers. It is only high quality certified seeds that can produce strong plants that can resist diseases and adverse climatic conditions (FAO, 1981)

Fifty three percent(53%)of the respondents obtaining their seed maize from their previous harvest has also been consistent with reports made by Walker *et al.(*1999a) that farmers in Ghana plant uncertified seeds saved by neighbours, bought from the local grain market or from their own saved seeds from previous harvest. Higher cost of certified seeds, fear of losing traditional varieties with unique characteristics and desire to grow new varieties were some reasons that farmers attributed for seed re-cycling(Walker *et al*.,1999a).Providing farmers with certified seeds regularly at a cost within the capability of the farmer will enhance productivity of the crop at all times.

The existing cropping system adopted by maize farmers in the study areas has showed that 94% of the respondents cultivated maize exclusively with only 6% of them intercropping maize with other crops

Maize intercropped with other crops is a practice mostly carried out by small- scale resource poor farmers and has a number of advantages such as maintenance of soil fertility, increased income, and proper utilization of land, control of weeds, diseases and insect pests (Paner, 1975; Mercado*et al.*, 1976). Maize intercropped with groundnuts can increase maize yield due to the ability of the groundnut plant to fix atmospheric nitrogen into the soil (Herrera*et al.*, 1975)

The prevalent cropping system across the study areas was sole cultivation of maize and it so, probably, because maize is increasingly becoming a crop cultivated for cash rather than for home consumption and with the ever increasing population in Ghana it means that many more people will demand for maize as it is one of the major staple food in the country (Tsigbey *et al.,* 2004). The higher percentage of the farmers cultivating maize exclusively agrees with reports made by the Ghana statistical service (GSS, 2002) that the abundance of fertile lands together with improved agronomical technologies and transportation network have made the transitional zone of Ghana a favourable place for commercial crop production.

Five (5) maize varieties namely, Abrotia, Abrohuma, Abeleehe, Yellow maize and Obaatanpa sourced from the respondents across the selected communities during the field survey were used for the study.

About 48% of the farmers cultivated Abrohuma maize variety, followed by Obaatanpa 28%, Abrotia 13%, and Yellow maize 6% with Abeleehe maize being the least cultivated variety. The research showed that majority of the farmers cultivates Abrohuma variety probably because it is one of the commercially produced cultivar (Paner, 1975). According to the responses of the farmers during the survey the reasons for cultivating maize is for consumption and for income and Abrohuma cultivar is very marketable.

Forty three percent(43%) of the maize farmers cultivate the variety of maize because it is marketable or has ready market, forty two percent(42%) reported that they cultivate their preferred variety because it is early maturing with only fifteen percent(15%) ascribing the reason to their choice of a variety as being both early maturing and marketable. Most of the responses of the farmers indicated that they cultivate a particular variety because it has ready market and this agrees with reports by Tsigbey *et al.* (2004) that maize is increasingly been cultivated as a cash crop rather than for home consumption and readily marketable nature of the commodity is one reason why most of the respondents cultivate a variety that is much demanded. The early maturing nature of some of the variety according to the farmers helps to guide against crop failure in the event of inadequate rainfall.

More than one third(39%) of the respondents across the study areas have being cultivating maize for more than ten(10) years, thirty – five percent (35%) of them seven to nine years, seventeen percent(17%) of them four to six years while only nine percent have been in the venture for between one to three years. This implies that an over whelming majority of the respondents are well experienced in maize cultivation.

Farming experience contributes positively to increase productivity and production efficiency. A farmer's regular involvement in the production of a same crop facilitates the practical use of modern technology and adoption of agronomic practices of production to increase output (Tsigbey *et al.*, 2004). Experience in growing one crop variety significantly leads to higher profit levels with minimal losses (Tsigbey *et al.*, 2004). Farmers who have cultivated the same crop over a long period of time are able to make accurate prediction on when to sow, the inputs to use, the quantity to use as well as the timing and when to use these inputs and therefore are more efficient in use of these inputs as compared to inexperienced farmers (Wilson, 1998)

The hectares of land cultivated per farmer interviewed in the study areas was in the range of one hectare and below to over four (4) hectares.This concurs to reports by Chamberlin (2007) that the Ghanaian agriculture is dominated by small holders with farm size of four (4) hectares or smaller. Most lands in Ghana are either communally owned or belong to families and this factor makes it quite difficult for persons who want to embark on commercial crop production to acquire large hectares of land (Chamberlin, 2007). Fragmented farm sizes make it difficult to use machines for land operations and with small farmlands much labour is invested with little output

From the field survey studies, maize farmers across the study areas store their maize in jute bags (63%), silos/sheds (30%) earthen wares (4%) and poly bags (3%).The study revealed that these storage materials were not treated with chemicals meant to protect stored maize against rot organisms and insect pests and this revelation has been consistent with the studies and earlier reports made by Tagne *et al*. (2008) that small holder maize farmers ignore some of the appropriate procedures involved in maintaining the seed quality during storage.

The results of the types of storage practices adopted by farmers across the study areas shows that 94% of the farmers do not follow the right procedures to conserve the genetic characteristics of the maize seed by ways of storing the seeds in cold rooms equipped with refrigerating facilities which is the surest method of protecting the seed genetic purity. This result therefore seems to emphasize report made by Daniel and Alaja,(2004) that medium and long term conservation of seed quality in gene banks as well as the delivery of high quality commercial seed lots under tropical climates is not possible without cooling facilities. In a country like Ghana, especially among resource poor small holder farmers, it is very difficult to store seeds under cold stores equipped with refrigerating facilities due to poverty, high cost of refrigerating facilities and frequent power shortages .Patronizing and using certified seed Maize can help to address the problem. Government should make certified seeds always available at an affordable price as this will be a step in the right direction towards addressing the issue.

The results of the method of seed treatment used the respondents across the study areas shows that most of the maize farmers (82%) treat their seed maize with chemicals (plant extract and synthetic chemicals) before seed storage. This result is consistent with the findings byDobie(1984) who argued that peasant farmers treat seeds with plant extracts and synthetic chemicals. Treatment of maize seeds with chemicals is a practice that is becoming more important and common among agricultural producers (Machado *etal.*, 2006). This is probably because of increasing incidence and prevalence of seed rot organisms andinsect pests of maize, which make it extremely difficult to preserve the seeds without chemical seed treatment. Synthetic chemicals seed treatment requires much skills and given the fact that most of the respondents (61%) in the study areas are without formal education implies that the appropriate handling and use of these chemicals is a serious problem and developing a botanical products with high efficacy which can serve as a close or better substitute to synthetic chemicals will be of much benefit to the farmers as they are easy to be prepared and applied with little skills.

Results provide important background information about the duration of seed storage by respondents. The greatest number of respondents (77%) stores their seed maize for a period of six (6) to seven (7) months. This can be explained by the fact that in the transitional zone of Ghana farming is done twice within a year and therefore farmers who re-cycle their own seeds store the seeds for only a short period of time as against the Savannah areas of the country where farmers store their seeds for relatively longer periods because crop cultivation is done once in a year.

Preserving the genetic purity of seeds in the tropics is a major challenge confronting the resource poor farmers for the seeds turn to deteriorate rapidly under high temperatures and relative humidity. High cost of refrigerating facilities in stores coupled with frequent power shortages are among the reasons why resource poor farmers in Ghana are unable to ensure seed security.

Peasant farmers manage the quality characteristics of their stored seeds by the use of several post harvest quality management intervention strategies including treating seeds with synthetic chemicals. If the efficacy of plant extracts on the quality characteristics of seed can be demonstrated to the farmers and with proper education they are most likely to switch to the use of botanicals seed treatment because botanicals are cheap, readily available and easy to prepare and apply

Results on the reasons ascribed by farmers for not conducting germination test of the seed maize prior to planting shows that an overwhelming majority of the respondents (70%) attributed the reason for not testing the germination potentials of the seeds prior to planting to no particular factor(s), 20% of them claimed they had faith in the ability of their seeds to germinate while 10% of them ascribed their reason to lack of technical knowledge to carry out germination test.

Germination test is generally meant to give an indication of how the seed will perform when planted and will help the farmer to decide on what quantity of seeds to use in planting and eventually the yield potential of the crop. From the survey, most of the farmers (61%) are without formal education and probably this is why all the farmers did not carry out germination test on their seeds because education enhances the managerial and technical skills of farmers as observed by Battese and Coelli (1995). Agricultural extension officers should occasionally conduct demonstrational lessons on how to test the germination potentials of seeds to farmers as a way of equipping them with the necessary skills in this regard

5.2 Effects of variety on seed maize quality characteristic before storage for four months (laboratory studies)

Laboratory studies involved an assessment of the present maize seed quality characteristics of the five different maize varieties obtained from the respondents across the study area during the field survey

The results on the maize seed moisture content, germination potentials, seed borne pathogens incidence and seed vigour (speed of germination) before storage indicated that there were no significant differences among treatments.

Seed maize moisture assessment at the start of the investigation showed that Abrotia seed maize variety produced the highest percentage moisture content (15.37%) and Abrohuma produced the lowest percentage moisture content (14.80%) among all the treatments. The similarities in the moisture content among the treatments can be attributed to the fact that the techniques employed by the farmers in drying the seed maize before storage were similar as revealed during the field survey.

There were no variations in percentage germination among treatments before storage. Abrotia and Abeleehe seed maize varieties produced the highest germination percentage (100%) while obaatanpa seed maize variety produced the lowest germination percentage (98.67%) among all the treatments. The treatments did not vary relative to germination and can be explained by the fact that the cultivation and post harvest management intervention methods of the farmers were similar as was observed during the field survey.

Results showed that seed borne pathogens incidence percent before storage did not vary among all the treatments. Obaatanpa seed maize produced the highest disease incident percent (37.37%) and Abrohuma seed maize variety produce the lowest disease incident (20.63%) among all treatment. The disease percent incidence among the treatments did not vary and was due to the fact that most of the farmers in the study area treated their seed maize with chemicals before storage as revealed during the survey studies and is consistent with the report by Dobie (1984) who argued that peasant farmers treat seeds with plant extracts and synthetic chemicals. Treatment of maize seeds with chemicals is a practice that is becoming more important and common among agricultural producers (Machado *et al.,* 2006).

Similarly, results on percentage seed vigour before storage showed that there were no variationsamong all treatments. The highest percentage (73.33%) of seed vigour was produced by Yellow maize and the lowest percentage vigour (53.33%) was produced Obaatanpa maize seed. Generally, percentage vigour was poor among all treatments. This can be explained by the fact that most of the farmers (88%) in the study area obtain their seed maize from the informal channel as revealed during the field study. This is consistent with an earlier report made by Almekinders *et al;* (1994) that about 80-90% of farmers in Sub-Sahara Africa obtain their seeds from informal source. According to Praveen *et al;* (2001) farmer-saved seeds are generally below standard in respect to seed vigour and seed health status.

Contrary, the effect of variety on other seed maize quality parameters, such as percentage deformed seed lots, percent pest damage and percent seed purity before storage indicated that there were clear variations among all treatments.

In terms of the effects of variety on percentage deformed seeds before storage, there were significant differences among treatments with the highest percentage (27.67%) of deformed seeds produced by Abrohuma seed maize. Yellow maize seed variety produced the lowest percentage (9.67%) of deformed seeds among all the treatments.

However, percentage of deformed seeds of Abrohuma was significantly different from yellow maize, Abrotia and Obaatanpa but was significantly similar to Abeleehe seed maize. Abrohuma seed maize showed more deformed seed among all treatment. The difference among the treatments interms of deformed seeds could be attributed to two factors, the genotype and the environment in which they were grown. Nerson (2000) attributed the high levels of deformed seed lots in uncertified maize seeds to genotype and environment.

Results on the effect of variety on seed purity before storage revealed that there was a variation among treatments. Abrotia seed maize produced the highest seed purity (60.43%) whist Abrohuma seed maize produced the lowest percent purity (50.27%). However, Obaatanpa and Abeleehe seed maize were not different significantly from each other and were not also significantly different from yellow maize, Abrohuma and Abrotia but yellow maize and Abrohuma were significantly different from Abrotia. The variation in terms of seed purity among the treatment can be explained by the fact that the cropping systems of the farmers in the study areas showed that some of the farmers intercrop maize with other crops with the result that parts of these crops are incidentally harvested with the maize accounting for the inpurities in the pure maize seed lots.

5.3 Effects of insecticides on seed maize quality after four months of storage

At the end of the storage period laboratory experiment was carried out to evaluate the maize seed lots quality characteristics after seed treatment and storage for four months following the same laboratory procedures for assessing the quality characteristics of the seeds before storage.

The results showed that all treatments, except for the untreated control, were all influenced by the (Insector T45). The results further revealed that yellow maize treated with insector T45 insecticide (synthetic) produced the highest percentage (96.33%) of germination and yellow maize treated with sweet potato leaf extract produced the lowest percentage (80.00%) of germination. The effects of synthetic chemicals on stored seed maize in this present work has agreed with reports by Machando *et.al*.(2006) that synthetic chemicals are effective in protecting the physiological quality of seeds. Ogbebor *et al;* (2005) in a study reported that seed treatment with plant extracts had no adverse effects on germination of the seeds.

Laboratory results on the effects of insecticides on the moisture content of seed maize after storage for four months showed that there were no significant difference among treatments. The untreated control in Abrotia produced the highest percentage (13.98%) of moisture content and yellow maize treated with insector T45 (synthetic) produced the lowest percentage (12.47%) of moisture content. The drop in the moisture level in all treatments both with and without chemical could be explained from the point of view of relative humidity and temperature within and without the storage atmosphere was which varied as the weather changes. The ability of the atmosphere to hold water vapour increases with a drop in temperature and all plant produce give off water into the atmosphere when the atmospheric humidity is too low.

This might be the reason why the seed maize content for sample seeds maize both treated with chemical and without chemical treatment reduced after four months of storage.

Results indicated that there were no significance differences among treatments for percent seed vigour. The highest percentage (69.47%) of seed vigour was produced by treating maize seeds with insector T45 (synthetic) and the lowest percentage (56.73%) of vigour was produced by the untreated control.

Seed vigour is one of the important factors usually used to determine seed quality because seed vigour determines seedling establishment. Seed with low vigour produce weaker seedlings which are easily affected by environmental stress (Ghassemi – Golezani, K. *et al*; (2010).

There were significant differences among treatments for percent bored /pest damage seeds. The highest percentage (58.50%) of bored seed was produced by the untreated control and lowest percentage (2.50%) of bored seed was produced by bitter leaf extract. However, insector T45 and bitter leaf extract were significantly similar to sweet potato leaf extract but significantly different from the untreated control. The effect of the botanicals on insect pests in this study has agreed with an earlier study by Khalid *et al;* (2002) that botanicals have insecticidal properties. Similarly findings on the efficacy of synthetic chemicals on insect pests of seed maize has agreed with an earlier report by Mote *et al.* (1995) that seed treated with insector T45 reduced the sucking pests population below the economic thresh hold level up to 40days after sowing. In a related study, *Zhang et al* (2011) reported that insector T45 seed treatment was effective in suppressing the whitefly population in cotton fields.

Results of the inhibitory effects of the test plant materials on hand and the synthetic chemical (insector T45) on the other hand on the percentage incidence of seed borne fungi pathogens that were recorded in the laboratory revealed the prevalence of

- *Colletotrichum granicola*
- *Colletotrichum gloesporoids*
- *Penicillium spp*

There were significant differences among treatments for percentage *Colletotrichum granicola*. The highest percentage (18.67%) of *Colletotrichum granicola* was produced by the untreated control and the lowest percent (4.00%) of *Colletotrichum granicola* was produced by the sweet potato leaf extract and the synthetic chemical, insector T45. However, insector T45, bitter leaf extract and sweet potato leaf extract were significantlysimilar but significantly different from the untreated control. According to Golob *et al.* (1990) storage pests and diseases are increasingly becoming resistant to synthetic chemical compounds and this report concur to why in this present finding sweet potato leaf extract performed better than insector T45

Colletotrichum gloeosporiods percentage incidence was not significantly different among treatments. The highest percentage (14.22%) of *Colletotrichum gloeosporiods* was produced by the untreated control and the lowest percentage (2.66%) of *Colletotrichum gloeosporiods* was produced by insector T45. Erasto *et al* (2006), in a study, reported that botanicals have both chemotherapy and insecticidal properties and thus confirm the efficacy of bitter leaf and sweet potato leaf extracts on *Colletotrichum gloeosporiods* in this present study.

Results on the effects of insecticides on the percentage incidence of *Penicillium Spp* revealed that there were significant differences among treatments. The highest (30.32%) of *Penicillium spp* was produced by the untreated control and lowest percentage (4.89%) of *Penicillium spp* was produced by insector T45 (synthetic). Meanwhile, all the chemical treatments (insector T45; Bitter leaf extract and sweet potato extract) were significantly similar but significantly different from untreated control. Ogbebor *et al*. (2005) in an earlier study of bitter leaf reported that they have antifungal activities which inhibit the growth of *Fusarium moniliforme* on seed maize (zea mays) as well as mycellial and conidal growth of *Colletotrichum gloeosporiods* in rubber trees. Similarly, extracts and powder formulation of bitter leaf effectively checked the growth, development and spread of *Rhizopus stolonifer* and*Fusarium oxysporum* pathogens, *Penicillium digitatum*, Micorpiriforms, *AspergillusNiger*and *Hominsthoporum solani*

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

A field survey was carried out during the major cropping season of 2013 -2014 in three selected communities within the transitional zone of Ghana to identify the channels from which smallholder maize farmers obtain their seed maize for planting and their management practices which affects the quality characteristics of the seed maize.

Laboratory experiments were carried out to assess the seed quality characteristics before and after the end of investigation following seed treatment and storage for a period of four months. The research revealed that majority of the smallholder maize farmers (53%) in the study areas recycles their seeds from previous harvest. Most of the farmers do not follow the right procedure to store their seeds, they saved their seeds in sheds, earthenware, jute bags and polybags which were not treated with chemicals to prevent attacks by insects and seed rot organisms. Some of the storage practices of the farmers, however, had no significant effect on the seed quality characteristics in respect to seed moisture percentage; seed germination percentage; percentage disease incidence and percentage seed vigour.

In terms of maize seed lots physical purity of the farmer- saved seeds, the study areas and were in the range of 52.87%.-60.43%

The research also indicated that the sample maize seed lots collected from the respondents were infested with four seed borne pathogens. The prevalent seed borne pathogens across the study areas were *Colletotrichum granicola*, *Colletotrichum gloeosporiods and Penicillium spp*. From the study farmers perceived that the use of synthetic chemical seed treatment before storage is the only effective means of protecting the seed maize against insect pest and seed rot organism. The study also revealed that farmers use synthetic chemicals to treat their seeds regularly because to them to store seed maize without the use of these chemicals is practically not possible. Farmers in the study area have no perfect substitute to the use of synthetic chemicals and are more likely to adapt to the use of botanical extracts if theyare properly educated on the downfalls of synthetic chemical seed treatment and the benefits of using botanical extracts instead.

Moreover, the presence of insect pests and seed rot organisms across the selected communities' means that maize seed storage faces some challenges that need to be extensively studied. It has now become imminent that all attempts must be made to always evaluate the potentials of botanical products on the post harvest quality characteristics of maize seeds stored in the study areas particularly and in Ghana generally. Seed security is a key to food security and maintaining the seed maize quality characteristics should form part of the routine management practices of maize farmer.

It was concluded after this investigation that leaf extracts from *Virnonia amygdalina* (bitter leaf) and *Ipomoea batatas* (sweet potatoes) have the ability to protect the seed maize quality characteristics during storage. This piece of work places emphasis around bitter leaf and sweet potato leaf in the public domain for further investigation as a seed maize protective material. These two products have the ability to serve as a suitable substitute to synthetic chemical seed treatment.

6.2 RECOMMENDATION

Based on the findings from this research conducted, the recommendations below are made

●The extracts from the leaves of *virnonia amygdalina*[bitter leaf] and *Ipomoeabatatas* [sweet potatoes leaf] can be used to preserve seed maize quality characteristics during storage as a suitable substitute to synthetic chemicals

●Other parts of the plants besides the leaves can be investigated for their potentials in protecting stored maize seeds against insect pests and seed rot organisms

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APPENDIX A

Questionnaire

Assessment of farmers' maize production systems, perceptions on constraints and other related problems encounter in the study areas.

Sample size: 100 maize farmers

1. Name of farmer……………… No of farmers…………………. Age…………………………Sex……………… Town/Village……………… District……………………. Region ……………………
2. What is your educational background?

a. primary b. JHS/SSS/Middle form four c. post sec/ tertiary d. No formal education

3. Do you cultivate maize?

a. Yes b. No

4. How long have you been cultivating maize?

a. 1-5Yrs b. 6-10Yrs c. Above 10 Yrs.

5. How many acres do you normally cultivating?

a.0 – 1 acres b.1.5 – 2 acres c. 2.5 – 3.5 acres d. above 4 acres]

6. How many times do you cultivate maize in a year?

a. once b. twice c. Others specify

7. Do you grow maize on the same land every year?

a. Yes No

8. Do you plant maize as a sole crop or intercrop?

a. sole crop   b. intercrop

9. If you plant maize with other crops, what are the other crops?

a. millet   b. Groundnut   c.Cassava   d.Others

10. What varieties do you grow?

a. yellow maize   b. Abrohuma   c. Abrotia   d. Abeleehe   e. Obaatanpa

11. Why?

a. mature early   b. marketable   c. both

12. How do you obtain your seed maize for planting?

A. Local grain market   b. Agro stores   c. own saved seeds d. friends   e. $NGO_{(s)}$

13. What do you do to the seeds before storing?

a. treat with botanicals   b. treat with synthetic chemicals   c Nothing

14. If you say you treat your seeds with synthetic chemicals, why are your reasons?

a. they are effective   b. they are cheap   c. others specify

15. Are synthetic chemicals better than other seed treatment methods?

a. Yes   b. No

16. What materials do you use to store your maize?

a. polybags b. jute bags c. silos/ sheet d. Earthen wares

17. Under what condition do you store your maize?

a. ambient temperature b. cold storage

18. How long do you store your maize (months)

A. 0-6 b. 7-12 c. Above 12

19. Do you determine the germination potentials of your seed maize prior to planting?

a. Yes b. No

20. If no what are your reasons

a. No reason b. Have faith in my seeds c. No knowledge to test

21. Do you harvest your crops soon after they are mature?

a. Yes b. No

22. If yes, why?

a. to prevent pests b. To prevent re- wetting

23. If you delay harvest, why?

a. to facilitate drying b. to facilitate harvesting c. others specify

24. How do you harvest your maize?

a. manually b. Machines c.Both

25. How do you shell your maize?

a. manually b. shelling machine c. both

26. Do you further dry your maize after shelling?

a. Yes b. No

27. On what do you further dry your maize if yes

a. plastic sheeting b. Wires mesh c. Cribs

28. Under what environment do you store your shelled maize after packaging?

a. cold room b. Open room c. Store room

29. Is your storage environment insect proof?

a. Yes b. No

30. If no, what do you do to prevent insects from entering?

a. nothing b. use plant repellents c. use synthetic chemicals

31. Is the storage environment moisture proof?

a. Yes b. No

32. If no what do you do to reduce higher moisture build up?

a. Nothing b. improving ventilation c. periodic drying of the maize

33. What is your cost of storage?

a. high b. average c low

34. Do you sort your seeds before storage?

a. Yes b. No

35. Why do you do sorting before storing?

a. to remove unwanted materials b. to remove damage seeds

APPENDIX B

List of respondents across the study areas within the transitional zone of the Ashanti and Brong- Ahafo Regions of Ghana

S/N	Region	District	Town	Farmer	Sex
1	Ashanti	Ejura/ Sekyedumasi	Santasi	Ismael Ussif	M
2	Ashanti	Ejura/ Sekyedumasi	Santasi	IssahUssif	M
3	Ashanti	Ejura/ Sekyedumasi	Santasi	AbassUssif	M
4	Ashanti	Ejura/ Sekyedumasi	Santasi	Hassan Ussif	M
5	Ashanti	Ejura/ Sekyedumasi	Santasi	IssahHaruna	M
6	Ashanti	Ejura/ Sekyedumasi	Santasi	Ibrahim Issah	M
7	Ashanti	Ejura/ Sekyedumasi	Santasi	Ibrahim Alhassan	M
8	Ashanti	Ejura/ Sekyedumasi	Dome	IddrisuAbdulai	M
9	Ashanti	Ejura/ Sekyedumasi	Dome	Abu Kassim	M
10	Ashanti	Ejura/ Sekyedumasi	Dome	YushauSeidu	M
11	Ashanti	Ejura/ Sekyedumasi	Dome	Seidu Abdul – Rahman	M
12	Ashanti	Ejura/ Sekyedumasi	Dome	AbdulaiSeidu	M
13	Ashanti	Ejura/ Sekyedumasi	Dome	Yahaya Rahman	M
14	Ashanti	Ejura/ Sekyedumasi	Dome	Baba Iddi	M
15	Ashanti	Ejura/ Sekyedumasi	Sirikikura	SalifuIssah	M
16	Ashanti	Ejura/ Sekyedumasi	Sirikikura	AdamaAwudu	M
17	Ashanti	Ejura/	Sirikikura	SeiduAbukari	M

		Sekyedumasi			
18	Ashanti	Ejura/ Sekyedumasi	Sirikikura	Majeed Mohammed	M
19	Ashanti	Ejura/ Sekyedumasi	Sirikikura	Mahamadu Ibrahim	M
20	Ashanti	Ejura/ Sekyedumasi	Sirikikura	Ibrahim Yakubu	M
21	Ashanti	Ejura/ Sekyedumasi	Sirikikura	NashiruAbdulai	M
22	Ashanti	Ejura/ Sekyedumasi	Heawawo	AbukariAlhassan	M
23	Ashanti	Ejura/ Sekyedumasi	Heawawo	Bintu Osman	F
24	Ashanti	Ejura/ Sekyedumasi	Heawawo	Yaro Francis	M
25	Ashanti	Ejura/ Sekyedumasi	Heawawo	Mohammed Haruna	M
26	Ashanti	Ejura/ Sekyedumasi	Heawawo	Muneratu Osman	M
27	Ashanti	Ejura/ Sekyedumasi	Heawawo	Mumuni Mohammed	F
28	Ashanti	Ejura/ Sekyedumasi	Heawawo	Abu Mohammed	M
29	Ashanti	Ejura/ Sekyedumasi	Timber Nkwanta	Shaibu Ibrahim	M
30	Ashanti	Ejura/ Sekyedumasi	Timber Nkwanta	AyiSulley	M
31	Ashanti	Ejura/ Sekyedumasi	Timber Nkwanta	Yussif Mustapha	F
32	Ashanti	Ejura/ Sekyedumasi	Timber Nkwanta	KandeIddrisu	M
33	Ashanti	Ejura/ Sekyedumasi	Timber Nkwanta	Emmanuel Addo	F
34	Ashanti	Ejura/ Sekyedumasi	Timber Nkwanta	Nana aduParko	M
35	Ashanti	Ejura/ Sekyedumasi	Timber Nkwanta	Abena Moses	M
36	Ashanti	Ejura/ Sekyedumasi	Anyeso	Adumako Felicia	F
37	Ashanti	Ejura/	Anyeso	IddrisuAlhassan	F

		Sekyedumasi			
38	Ashanti	Ejura/ Sekyedumasi	Anyeso	TijaniAbukari	M
39	Ashanti	Ejura/ Sekyedumasi	Anyeso	WumbeiFuseini	M
40	Ashanti	Ejura/ Sekyedumasi	Anyeso	Mary Abdul Salam	F
41	Ashanti	Ejura/ Sekyedumasi	Anyeso	Yakubu Moses	F
42	Ashanti	Ejura/ Sekyedumasi	Nkwanta	IssahakaZaman	M
43	Ashanti	Ejura/ Sekyedumasi	Nkwanta	Adam Iddrisu	M
44	Ashanti	Ejura/ Sekyedumasi	Nkwanta	KwadwoBoateng	M
45	Ashanti	Ejura/ Sekyedumasi	Nkwanta	Ben Suglo	M
46	Ashanti	Ejura/ Sekyedumasi	Nkwanta	AkwasiKudom	M
47	Ashanti	Ejura/ Sekyedumasi	Nkwanta	Yaw Mensah	M
48	Ashanti	Ejura/ Sekyedumasi	Aprante	Adam Karim	M
49	Ashanti	Ejura/ Sekyedumasi	Aprante	Kwakye John	M
50	Ashanti	Ejura/ Sekyedumasi	Aprante	HamzaAbubakari	M
51	Ashanti	Ejura/ Sekyedumasi	Aprante	OseiBrempong	M
52	Ashanti	Ejura/ Sekyedumasi	Aprante	DawdaSeidu	M
53	Ashanti	Ejura/ Sekyedumasi	Aprante	Rufia Mohammed	M
54	Ashanti	Ejura/ Sekyedumasi	Kyeredaaso	Christopher John	M
55	Ashanti	Ejura/ Sekyedumasi	Kyeredaaso	FuseiniHamza	M
56	Ashanti	Ejura/ Sekyedumasi	Kyeredaaso	Mensah Samuel	M
57	Ashanti	Ejura/	Kyeredaaso	Yeboah Isaac	M

		Sekyedumasi			
58	Ashanti	Ejura/ Sekyedumasi	Kyeredaaso	John Evans	M
59	Ashanti	Ejura/ Sekyedumasi	Kyeredaaso	AdjeiBoateng	M
60	Ashanti	Ejura/ Sekyedumasi	Nkranpo	Stephen Addo	M
61	Ashanti	Ejura/ Sekyedumasi	Nkranpo	NuruAlhassan	M
62	Ashanti	Ejura/ Sekyedumasi	Nkranpo	Morro Issah	M
63	Ashanti	Ejura/ Sekyedumasi	Nkranpo	AwuniKolan	M
64	Ashanti	Ejura/ Sekyedumasi	Nkranpo	DramaniMumuni	M
65	Ashanti	Ejura/ Sekyedumasi	Nkranpo	Yeboah Samuel	M
66	Brong - Ahafo	Nkoranza	Drumankuma	George Nsiah	M
67	Brong - Ahafo	Nkoranza	Drumankuma	YeboahAfia	F
68	Brong - Ahafo	Nkoranza	Drumankuma	Mohammed Salifu	M
69	Brong - Ahafo	Nkoranza	Drumankuma	Baba Karim	M
70	Brong - Ahafo	Nkoranza	Drumankuma	Aziz Fuseini	M
71	Brong - Ahafo	Nkoranza	Drumankuma	AbukariSalifu	M
72	Brong - Ahafo	Nkoranza	Drumankuma	AkosuaAdofua	M
73	Brong - Ahafo	Nkoranza	Bradi	Kojo Asante	M
74	Brong - Ahafo	Nkoranza	Bradi	Karim Toro	M
75	Brong - Ahafo	Nkoranza	Bradi	Ibrahim Iddi	M
76	Brong - Ahafo	Nkoranza	Bradi	Adongo Bongo	M
77	Brong -	Nkoranza	Bradi	IssifuIddrisu	M

	Ahafo				
78	Brong - Ahafo	Nkoranza	Bradi	Eric Atimbila	M
79	Brong - Ahafo	Nkoranza	Bradi	Kwame Peprah	M
80	Brong - Ahafo	Nkoranza	Boamang	BoamaAfia	F
81	Brong - Ahafo	Nkoranza	Boamang	Margaret Boahen	F
82	Brong - Ahafo	Nkoranza	Boamang	KwabenaDede	M
83	Brong - Ahafo	Nkoranza	Boamang	OppongFosu	M
84	Brong - Ahafo	Nkoranza	Boamang	Elder OseiGyebaa	M
85	Brong - Ahafo	Nkoranza	Boamang	Yaw Kpalinpart	M
86	Brong - Ahafo	Nkoranza	Boamang	KwakuEffah	M
87	Brong - Ahafo	Nkoranza	Akontedumasi	AlhassanChaaka	M
88	Brong - Ahafo	Nkoranza	Akontedumasi	AliduMahama	M
89	Brong - Ahafo	Nkoranza	Akontedumasi	AzagadiYakubu	M
90	Brong - Ahafo	Nkoranza	Akontedumasi	Suglo Justice	M
91	Brong - Ahafo	Nkoranza	Akontedumasi	Kofi Bio	M
92	Brong - Ahafo	Nkoranza	Akontedumasi	William Owusu	M
93	Brong - Ahafo	Nkoranza	Akontedumasi	Awuni James	M
94	Brong - Ahafo	Nkoranza	Taahu	Moses Ayamga	M
95	Brong - Ahafo	Nkoranza	Taahu	Frank Adu	M
96	Brong - Ahafo	Nkoranza	Taahu	Samuel Yeboah	M
97	Brong -	Nkoranza	Taahu	AmanduSeidu	M

	Ahafo				
98	Brong - Ahafo	Nkoranza	Taahu	AbulaiZakari	M
99	Brong - Ahafo	Nkoranza	Taahu	AlhassanKojo	M
100	Brong - Ahafo	Nkoranza	Taahu	AlhassanKojo	M

Appendix B1. Correlations analysis between Age of farmers and number of years of experience in maize cultivation

			Age of farmer	number of years of experience in maize cultivation
Kendall's tau_b	Age of farmer	Correlation Coefficient	1.000	.
		Sig. (2-tailed)	.	.
		N	100	0
	number of years of experience in maize cultivation	Correlation Coefficient	.	.
		Sig. (2-tailed)	.	.
		N	0	0
Spearman's rho	Age of farmer	Correlation Coefficient	1.000	.
		Sig. (2-tailed)	.	.
		N	100	0
	number of years of experience in maize cultivation	Correlation Coefficient	.	.
		Sig. (2-tailed)	.	.
		N	0	0

APPENDIX C

ANOVA AND OTHER LABORATORY TREATMENTS

ANOVA.BEFORE MAIZE TRANSFMD

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Completely Randomized Anova deformeds

Source	DF	SS	MS	F	P
variety	4	796.267	199.067	96.32	0.0000
Error	10	20.667	2.067		
Total	14	816.933			

Grand Mean 20.267 CV 7.09

Homogeneity of Variances	F	P
Levene's Test	0.45	0.7736
O'Brien's Test	0.20	0.9338
Brown and Forsythe Test	0.07	0.9909

Welch's Test for Mean Differences

Source	DF	F	P
variety	4.0	86.68	0.0001
Error	5.0		

Component of variance for between groups   65.6667

Effective cell size   3.0

variety   Mean

1   9.667

2 27.667

3 23.333

4 27.000

5 13.667

Observations per Mean   3

Standard Error of a Mean   0.8300

Std Error (Diff of 2 Means) 1.1738

Completely Randomized AOV for tdeformed

Source	DF	SS	MS	F	P
variety	4	11.1817	2.79543	98.43	0.0000
Error	10	0.2840	0.02840		
Total	14	11.4657			

Grand Mean 4.4161   CV 3.82

Homogeneity of Variances   F   P

Levene's Test	0.59	0.6769
O'Brien's Test	0.26	0.8953
Brown and Forsythe Test	0.10	0.9803

Welch's Test for Mean Differences

Source	**DF**	**F**	**P**
variety	4.0	71.94	0.0001
Error	4.9		

Component of variance for between groups 0.92234

Effective cell size 3.0

variety	**Mean**
1	3.1055
2	5.2592
3	4.8287
4	5.1943
5	3.6929

Observations per Mean 3

Standard Error of a Mean 0.0973

Std Error (Diff of 2 Means) 0.1376

Completely Randomized ANOVA for moisturel

Source	DF	SS	MS	F	P
variety	4	0.73980	0.18495	0.46	0.7657
Error	10	4.04693	0.40469		
Total	14	4.78673			

Grand Mean 15.057 CV 4.23

Homogeneity of Variances	F	P
Levene's Test	2.28	0.1325
O'Brien's Test	1.01	0.4456
Brown and Forsythe Test	0.74	0.5838

Welch's Test for Mean Differences

Source	DF	F	P
variety	4.0	1.32	0.3842
Error	4.6		

Component of variance for between groups -0.07325

Effective cell size 3.0

variety	Mean
1	15.260

2 14.800

3 15.377

4 14.950

5 14.897

Observations per Mean 3

Standard Error of a Mean 0.3673

Std Error (Diff of 2 Means) 0.5194

Completely Randomized AOV for tmoisture

Source	DF	SS	MS	F	P
variety	4	0.01244	0.00311	0.46	0.7666
Error	10	0.06825	0.00682		
Total	14	0.08069			

Grand Mean 3.8796 CV 2.13

Homogeneity of Variances	F	P
Levene's Test	2.31	0.1289
O'Brien's Test	1.03	0.4395
Brown and Forsythe Test	0.74	0.5840

Welch's Test for Mean Differences

Source	DF	F	P
variety	4.0	1.32	0.3837
Error	4.6		

Component of variance for between groups -0.00124

Effective cell size 3.0

variety	Mean
1	3.9061
2	3.8470
3	3.9211
4	3.8656
5	3.8581

Observations per Mean 3

Standard Error of a Mean 0.0477

Std Error (Diff of 2 Means) 0.0675

Completely Randomized AOV for pergermin

Source	DF	SS	MS	F	P
variety	4	3.73333	0.93333	2.33	0.1264
Error	10	4.00000	0.40000		
Total	14	7.73333			

Grand Mean 99.533   CV 0.64

Homogeneity of Variances   F   P

Levene's Test   3.00   0.0723

O'Brien's Test   1.33   0.3232

Brown and Forsythe Test   0.58   0.6819

Welch's Test for Mean Differences

Source	**DF**	**F**	**P**
variety	4.0	M	0.0000
Error	M		

Component of variance for between groups   0.17778

Effective cell size   3.0

variety	**Mean**
1	99.67
2	99.33
3	100.00
4	100.00
5	98.67

Observations per Mean   3

Standard Error of a Mean 0.3651

Std Error (Diff of 2 Means) 0.5164

Completely Randomized AOV for tpergermi

Source	DF	SS	MS	F	P
variety	4	0.00941	0.00235	2.33	0.1269
Error	10	0.01010	0.00101		
Total	14	0.01951			

Grand Mean 9.9766 CV 0.32

Homogeneity of Variances	F	P
Levene's Test	3.00	0.0723
O'Brien's Test	1.33	0.3232
Brown and Forsythe Test	0.58	0.6819

Welch's Test for Mean Differences

Source	DF	F	P
variety	4.0	M	0.0000
Error	M		

Component of variance for between groups 4.472E-04

Effective cell size 3.0

variety	Mean
1	9.983
2	9.966
3	10.000
4	10.000
5	9.933

Observations per Mean 3

Standard Error of a Mean 0.0183

Std Error (Diff of 2 Means) 0.0260

Completely Randomized AOV for perincide

Source	DF	SS	MS	F	P
variety	4	491.43	122.857	1.79	0.2084
Error	10	688.18	68.818		
Total	14	1179.61			

Grand Mean 28.927 CV 28.68

Homogeneity of Variances F P

Levene's Test	1.92	0.1839
O'Brien's Test	0.85	0.5237
Brown and Forsythe Test	0.72	0.5995

Welch's Test for Mean Differences

Source	**DF**	**F**	**P**
variety	4.0	4.81	0.0787
Error	4.0		

Component of variance for between groups 18.0131

Effective cell size 3.0

variety	**Mean**
1	25.633
2	20.633
3	28.500
4	32.500
5	37.367

Observations per Mean 3

Standard Error of a Mean 4.7895

Std Error (Diff of 2 Means) 6.7734

Completely Randomized AOV for tperincid

Source	DF	SS	MS	F	P
variety	4	4.6594	1.16484	1.65	0.2365
Error	10	7.0489	0.70489		
Total	14	11.7083			

Grand Mean 5.3053   CV 15.83

Homogeneity of Variances	F	P
Levene's Test	2.11	0.1536
O'Brien's Test	0.94	0.4798
Brown and Forsythe Test	0.74	0.5864

Welch's Test for Mean Differences

Source	DF	F	P
variety	4.0	3.68	0.1173
Error	4.0		

Component of variance for between groups   0.15332

Effective cell size   3.0

variety	Mean
1	4.9412
2	4.5052

3	5.3035
4	5.6636
5	6.1128

Observations per Mean 3

Standard Error of a Mean 0.4847

Std Error (Diff of 2 Means) 0.6855

Completely Randomized AOV for pestdamag

Source	**DF**	**SS**	**MS**	**F**	**P**
variety	4	893.067	223.267	108.03	0.0000
Error	10	20.667	2.067		
Total	14	913.733			

Grand Mean 19.533 CV 7.36

Homogeneity of Variances	**F**	**P**
Levene's Test	1.29	0.3376
O'Brien's Test	0.57	0.6885
Brown and Forsythe Test	0.21	0.9267

Welch's Test for Mean Differences

Source DF F P

variety	4.0	94.64	0.0001
Error	4.9		

Component of variance for between groups 73.7333

Effective cell size 3.0

variety	**Mean**
1	8.667
2	27.333
3	22.000
4	27.333
5	12.333

Observations per Mean 3

Standard Error of a Mean 0.8300

Std Error (Diff of 2 Means) 1.1738

Completely Randomized AOV for tpestdama

Source	**DF**	**SS**	**MS**	**F**	**P**
variety	4	13.0635	3.26589	93.94	0.0000
Error	10	0.3477	0.03477		
Total	14	13.4112			

Grand Mean 4.3173   CV 4.32

Homogeneity of Variances	**F**	**P**
Levene's Test	2.13	0.1512
O'Brien's Test	0.95	0.4761
Brown and Forsythe Test	0.35	0.8366

Welch's Test for Mean Differences

Source	**DF**	**F**	**P**
variety	4.0	71.61	0.0002
Error	4.9		

Component of variance for between groups   1.07704

Effective cell size   3.0

variety	**Mean**
1	2.9397
2	5.2273
3	4.6896
4	5.2268
5	3.5032

Observations per Mean   3

Standard Error of a Mean   0.1077

Std Error (Diff of 2 Means) 0.1522

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Completely Randomized AOV for spurity

Source	DF	SS	MS	F	P
variety	4	175.371	43.8427	6.13	0.0093
Error	10	71.513	7.1513		
Total	14	246.884			

Grand Mean 54.820 CV 4.88

Homogeneity of Variances	F	P
Levene's Test	3.58	0.0463
O'Brien's Test	1.59	0.2507
Brown and Forsythe Test	1.31	0.3309

Welch's Test for Mean Differences

Source	DF	F	P
variety	4.0	16.59	0.0050
Error	4.8		

Component of variance for between groups 12.2304

Effective cell size 3.0

variety	**Mean**
1	52.867
2	50.267
3	60.433
4	56.267
5	54.267

Observations per Mean 3

Standard Error of a Mean 1.5439

Std Error (Diff of 2 Means) 2.1835

Completely Randomized AOV for tspurity

Source	**DF**	**SS**	**MS**	**F**	**P**
variety	4	0.78800	0.19700	6.07	0.0096
Error	10	0.32442	0.03244		
Total	14	1.11242			

Grand Mean 7.3990 CV 2.43

Homogeneity of Variances	F	P
Levene's Test	3.58	0.0463
O'Brien's Test	1.59	0.2506
Brown and Forsythe Test	1.27	0.3455

Welch's Test for Mean Differences

Source	DF	F	P
variety	4.0	17.05	0.0047
Error	4.8		

Component of variance for between groups 0.05485

Effective cell size 3.0

variety	Mean
1	7.2708
2	7.0896
3	7.7735
4	7.4951
5	7.3662

Observations per Mean 3

Standard Error of a Mean 0.1040

Std Error (Diff of 2 Means) 0.1471

Completely Randomized AOV for vigour

Source	DF	SS	MS	F	P
variety	4	733.33	183.333	0.71	0.6063
Error	10	2600.00	260.000		
Total	14	3333.33			

Grand Mean 66.667   CV 24.19

Homogeneity of Variances	F	P
Levene's Test	1.96	0.1763
O'Brien's Test	0.87	0.5132
Brown and Forsythe Test	0.52	0.7209

Welch's Test for Mean Differences

Source	DF	F	P
variety	4.0	0.30	0.8684
Error	4.7		

Component of variance for between groups -25.5556

Effective cell size 3.0

variety   Mean

1 73.333

2 70.000

3 66.667

4 70.000

5 53.333

Observations per Mean 3

Standard Error of a Mean 9.3095

Std Error (Diff of 2 Means) 13.166

Completely Randomized AOV for tvigour

Source	DF	SS	MS	F	P
variety	4	3.5362	0.88405	0.81	0.5457
Error	10	10.8944	1.08944		
Total	14	14.4306			

Grand Mean 8.1058 CV 12.88

Homogeneity of Variances	F	P
Levene's Test	2.35	0.1248
O'Brien's Test	1.04	0.4321
Brown and Forsythe Test	0.69	0.6174

Welch's Test for Mean Differences

Source	DF	F	P
variety	4.0	0.31	0.8625
Error	4.7		

Component of variance for between groups -0.06847

Effective cell size 3.0

variety	Mean
1	8.5331
2	8.3199
3	8.1597
4	8.3523
5	7.1642

Observations per Mean 3

Standard Error of a Mean 0.6026

Std Error (Diff of 2 Means) 0.8522

ANOVA.AFTER MAIZE TRANSFMD

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Analysis of Variance Table for GERMINATI ON

Source	DF	SS	MS	F	P
VARIETIES	4	144.2	36.058	0.12	0.9758

INSECTICI	3	1113.2	371.067	1.20	0.3219
VARIETIES*INSECTICI	12	445.0	37.081	0.12	0.9998
Error	40	12361.3	309.033		
Total	59	14063.7			

Grand Mean 87.267 CV 20.14

Analysis of Variance Table for TGERMINAT

Source	**DF**	**SS**	**MS**	**F**	**P**
VARIETIES	4	0.5404	0.13510	0.13	0.9689
INSECTICI	3	3.7424	1.24747	1.24	0.3087
VARIETIES*INSECTICI	12	1.5319	0.12766	0.13	0.9998
Error	40	40.3138	1.00784		
Total	59	46.1285			

Grand Mean 9.3004 CV 10.79

Analysis of Variance Table for MOISTUREC

Source	**DF**	**SS**	**MS**	**F**	**P**
VARIETIES	4	5.7057	1.42641	1.93	0.1236
INSECTICI	3	2.8132	0.93775	1.27	0.2972

VARIETIES*INSECTICI	12	0.8307	0.06922	0.09	1.0000
Error	40	29.5061	0.73765		
Total	59	38.8556			

Grand Mean 13.324   CV 6.45

Analysis of Variance Table for TMOISTURE

Source	**DF**	**SS**	**MS**	**F**	**P**
VARIETIES	4	0.11003	0.02751	1.99	0.1138
INSECTICI	3	0.05168	0.01723	1.25	0.3047
VARIETIES*INSECTICI	12	0.01486	0.00124	0.09	1.0000
Error	40	0.55155	0.01379		
Total	59	0.72812			

Grand Mean 3.6485   CV 3.22

Analysis of Variance Table for SEEDVIGOUR

Source	**DF**	**SS**	**MS**	**F**	**P**
VARIETIES	4	1533.8	383.442	0.76	0.5596
INSECTICI	3	1481.9	493.978	0.97	0.4141
VARIETIES*INSECTICI	12	1334.9	111.242	0.22	0.9965

Error	40	20267.3	506.683		
Total	59	24617.9			

Grand Mean 61.033 CV 36.88

Analysis of Variance Table for TSEEDVIGO

Source	**DF**	**SS**	**MS**	**F**	**P**
VARIETIES	4	7.041	1.76025	0.71	0.5875
INSECTICI	3	7.259	2.41977	0.98	0.4113
VARIETIES*INSECTICI	12	7.105	0.59208	0.24	0.9947
Error	40	98.663	2.46656		
Total	59	120.068			

Grand Mean 7.6832 CV 20.44

Analysis of Variance Table for boredseed

Source	**DF**	**SS**	**MS**	**F**	**P**
VARIETIES	4	415.1	103.77	0.12	0.9731
INSECTICI	3	20385.1	6795.04	8.10	0.0002
VARIETIES*INSECTICI	12	3313.9	276.16	0.33	0.9790

Error	40	33539.3	838.48		
Total	59	57653.4			

Grand Mean 21.400 CV 135.31

Analysis of Variance Table for Tboredsee

Source	**DF**	**SS**	**MS**	**F**	**P**
VARIETIES	4	2.755	0.6887	0.09	0.9838
INSECTICI	3	209.867	69.9555	9.54	0.0001
VARIETIES*INSECTICI	12	31.158	2.5965	0.35	0.9720
Error	40	293.240	7.3310		
Total	59	537.020			

Grand Mean 3.5284 CV 76.74

Analysis of Variance Table for collect

Source	**DF**	**SS**	**MS**	**F**	**P**
VARIETIES	4	355.40	88.850	0.68	0.6114
INSECTICI	3	2374.40	791.467	6.04	0.0017
VARIETIES*INSECTICI	12	130.45	10.871	0.08	1.0000
Error	40	5243.60	131.090		

Total 59 8103.85

Grand Mean 7.7753 CV 147.25

Analysis of Variance Table for Tcollect

Source	DF	SS	MS	F	P
VARIETIES	4	14.756	3.6891	1.03	0.4019
INSECTICI	3	30.486	10.1618	2.85	0.0495
VARIETIES*INSECTICI	12	1.772	0.1477	0.04	1.0000
Error	40	142.775	3.5694		
Total	59	189.789			

Grand Mean 2.2610 CV 83.56

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Analysis of Variance Table for gleo

Source	DF	SS	MS	F	P
VARIETIES	4	944.65	236.163	2.26	0.0794
INSECTICI	3	1270.69	423.565	4.06	0.0131

VARIETIES*INSECTICI	12	666.94	55.578	0.53	0.8806
Error	40	4176.71	104.418		
Total	59	7058.99			

Grand Mean 6.3315 CV 161.39

Analysis of Variance Table for Tgleo

Source	DF	SS	MS	F	P
VARIETIES	4	35.669	8.91726	2.92	0.0330
INSECTICI	3	15.873	5.29105	1.73	0.1760
VARIETIES*INSECTICI	12	8.443	0.70362	0.23	0.9956
Error	40	122.254	3.05636		
Total	59	182.240			

Grand Mean 1.9479 CV 89.75

Analysis of Variance Table for pen

Source	DF	SS	MS	F	P
VARIETIES	4	1350.5	337.63	2.75	0.0415
INSECTICI	3	5829.4	1943.12	15.80	0.0000
VARIETIES*INSECTICI	12	480.2	40.02	0.33	0.9800
Error	40	4918.3	122.96		

Total	59	12578.4

Grand Mean 13.442   CV 82.49

Analysis of Variance Table for Tpen

Source	**DF**	**SS**	**MS**	**F**	**P**
VARIETIES	4	50.303	12.5757	4.52	0.0042
INSECTICI	3	65.973	21.9909	7.90	0.0003
VARIETIES*INSECTICI	12	5.107	0.4256	0.15	0.9994
Error	40	111.321	2.7830		
Total	59	232.703			

Grand Mean 3.1723   CV 52.59

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LSD All-Pairwise Comparisons Test of deformeds by variety

variety	**Mean**	**Homogeneous Groups**
2	27.667	A
4	27.000	AB
3	23.333	B

5 13.667   C

1 9.6667   D

Alpha   0.01   Standard Error for Comparison 1.1738

Critical T Value 3.169   Critical Value for Comparison 3.7201

There are 4 groups (A, B, etc.) in which the means

are not significantly different from one another.

LSD All-Pairwise Comparisons Test of tdeformed by variety

variety   Mean Homogeneous Groups

2 5.2592 A

4 5.1943 A

3 4.8287 A

5 3.6929   B

1 3.1055   C

Alpha   0.01   Standard Error for Comparison 0.1376

Critical T Value 3.169   Critical Value for Comparison 0.4361

There are 3 groups (A, B, etc.) in which the means

are not significantly different from one another.

LSD All-Pairwise Comparisons Test of moisturel by variety

variety   Mean Homogeneous Groups

3 15.377 A

1 15.260 A

4 14.950 A

5 14.897 A

2 14.800 A

Alpha 0.01 Standard Error for Comparison 0.5194

Critical T Value 3.169 Critical Value for Comparison 1.6462

There are no significant pairwise differences among the means.

LSD All-Pairwise Comparisons Test of tmoisture by variety

variety Mean Homogeneous Groups

3 3.9211 A

1 3.9061 A

4 3.8656 A

5 3.8581 A

2 3.8470 A

Alpha 0.01 Standard Error for Comparison 0.0675

Critical T Value 3.169 Critical Value for Comparison 0.2138

There are no significant pairwise differences among the means.

LSD All-Pairwise Comparisons Test of pergermin by variety

variety Mean Homogeneous Groups

3 100.00 A

4 100.00 A

1 99.667 A

2 99.333 A

5 98.667 A

Alpha 0.01 Standard Error for Comparison 0.5164

Critical T Value 3.169 Critical Value for Comparison 1.6366

There are no significant pairwise differences among the means.

LSD All-Pairwise Comparisons Test of tpergermi by variety

variety Mean Homogeneous Groups

3 10.000 A

4 10.000 A

1 9.9833 A

2 9.9665 A

5 9.9331 A

Alpha 0.01 Standard Error for Comparison 0.0260

Critical T Value 3.169 Critical Value for Comparison 0.0822

There are no significant pairwise differences among the means.

LSD All-Pairwise Comparisons Test of perincide by variety

variety Mean Homogeneous Groups

5 37.367 A

4 32.500 A

3 28.500 A

1 25.633 A

2 20.633 A

Alpha 0.01 Standard Error for Comparison 6.7734

Critical T Value 3.169 Critical Value for Comparison 21.467

There are no significant pairwise differences among the means.

LSD All-Pairwise Comparisons Test of tperincid by variety

variety	Mean	Homogeneous Groups
5	6.1128	A
4	5.6636	A
3	5.3035	A
1	4.9412	A
2	4.5052	A

Alpha 0.01 Standard Error for Comparison 0.6855

Critical T Value 3.169 Critical Value for Comparison 2.1726

There are no significant pairwise differences among the means.

LSD All-Pairwise Comparisons Test of pestdamag by variety

variety	Mean	Homogeneous Groups
2	27.333	A
4	27.333	A
3	22.000	B
5	12.333	C

1 8.6667 C

Alpha 0.01 Standard Error for Comparison 1.1738

Critical T Value 3.169 Critical Value for Comparison 3.7201

There are 3 groups (A, B, etc.) in which the means

are not significantly different from one another.

LSD All-Pairwise Comparisons Test of tpestdama by variety

variety	Mean	Homogeneous Groups
2	5.2273	A
4	5.2268	A
3	4.6896	B
5	3.5032	C
1	2.9397	D

Alpha 0.01 Standard Error for Comparison 0.1522

Critical T Value 3.169 Critical Value for Comparison 0.4825

There are 4 groups (A, B, etc.) in which the means

are not significantly different from one another.

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LSD All-Pairwise Comparisons Test of spurity by variety

variety	Mean	Homogeneous Groups
3	60.433	A
4	56.267	AB
5	54.267	AB
1	52.867	B
2	50.267	B

Alpha 0.01 Standard Error for Comparison 2.1835

Critical T Value 3.169 Critical Value for Comparison 6.9200

There are 2 groups (A and B) in which the means

are not significantly different from one another.

LSD All-Pairwise Comparisons Test of tspurity by variety

variety	Mean	Homogeneous Groups
3	7.7735	A
4	7.4951	AB
5	7.3662	AB
1	7.2708	B
2	7.0896	B

Alpha 0.01 Standard Error for Comparison 0.1471

Critical T Value 3.169 Critical Value for Comparison 0.4661

There are 2 groups (A and B) in which the means

are not significantly different from one another.

LSD All-Pairwise Comparisons Test of vigour by variety

variety	Mean	Homogeneous Groups
1	73.333	A
2	70.000	A
4	70.000	A
3	66.667	A
5	53.333	A

Alpha 0.01 Standard Error for Comparison 13.166

Critical T Value 3.169 Critical Value for Comparison 41.725

There are no significant pairwise differences among the means.

LSD All-Pairwise Comparisons Test of tvigour by variety

variety	Mean	Homogeneous Groups
1	8.5331	A
4	8.3523	A
2	8.3199	A

3 8.1597 A

5 7.1642 A

Alpha 0.01 Standard Error for Comparison 0.8522

Critical T Value 3.169 Critical Value for Comparison 2.7010

There are no significant pairwise differences among the means.

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Tukey HSD All-Pairwise Comparisons Test of GERMINATI for VARIETIES

VARIETIES Mean Homogeneous Groups

3 89.667 A

4 88.333 A

1 86.583 A

2 86.500 A

5 85.250 A

Alpha 0.01 Standard Error for Comparison 7.1767

Critical Q Value 4.925 Critical Value for Comparison 24.995

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of GERMINATI for INSECTICI

INSECTICI Mean Homogeneous Groups

1 94.267 A

3 86.933 A

4 85.133 A

2 82.733 A

Alpha 0.01 Standard Error for Comparison 6.4191

Critical Q Value 4.695 Critical Value for Comparison 21.312

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of GERMINATI for VARIETIES*INSECTICI

VARIETIES	INSECTICI	Mean	Homogeneous Groups
1	1	96.333	A
3	3	95.000	A
2	1	94.667	A
4	1	94.000	A
5	1	93.333	A
3	1	93.000	A
4	3	89.667	A
3	4	88.333	A
4	4	88.333	A
2	3	86.333	A
1	4	85.000	A
1	2	85.000	A
2	2	84.333	A
5	3	83.667	A

5	4	83.333	A
3	2	82.333	A
4	2	81.333	A
2	4	80.667	A
5	2	80.667	A
1	3	80.000	A

Alpha 0.01 Standard Error for Comparison 14.353

Critical Q Value 6.172 Critical Value for Comparison 62.640

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of TGERMINAT for VARIETIES

VARIETIES	Mean	Homogeneous Groups
3	9.4479	A
4	9.3692	A
1	9.2511	A
2	9.2503	A
5	9.1837	A

Alpha 0.01 Standard Error for Comparison 0.4098

Critical Q Value 4.925 Critical Value for Comparison 1.4274

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of TGERMINAT for INSECTICI

INSECTICI	Mean	Homogeneous Groups
1	9.7055	A
3	9.2739	A
4	9.1918	A
2	9.0305	A

Alpha 0.01 Standard Error for Comparison 0.3666

Critical Q Value 4.695 Critical Value for Comparison 1.2171

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of TGERMINAT for VARIETIES*INSECTICI

VARIETIES	INSECTICI	Mean	Homogeneous Groups
1	1	9.8139	A
3	3	9.7442	A
2	1	9.7278	A

4	1	9.6914	A
5	1	9.6544	A
3	1	9.6403	A
4	3	9.4419	A
3	4	9.3904	A
4	4	9.3832	A
2	3	9.2451	A
1	4	9.1885	A
1	2	9.1549	A
2	2	9.1109	A
5	3	9.0909	A
5	4	9.0798	A
3	2	9.0166	A
4	2	8.9602	A
2	4	8.9173	A
5	2	8.9098	A
1	3	8.8472	A

Alpha 0.01 Standard Error for Comparison 0.8197

Critical Q Value 6.172 Critical Value for Comparison 3.5772

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of MOISTUREC for VARIETIES

VARIETIES	Mean	Homogeneous Groups
4	13.642	A
3	13.588	A
2	13.483	A
1	13.001	A
5	12.906	A

Alpha 0.01 Standard Error for Comparison 0.3506

Critical Q Value 4.925 Critical Value for Comparison 1.2212

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of MOISTUREC for INSECTICI

INSECTICI	Mean	Homogeneous Groups
3	13.545	A
4	13.514	A
2	13.215	A
1	13.023	A

Alpha 0.01 Standard Error for Comparison 0.3136

Critical Q Value 4.695 Critical Value for Comparison 1.0412

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of MOISTUREC for VARIETIES*INSECTICI

VARIETIES	INSECTICI	Mean	Homogeneous Groups
3	4	13.977	A
4	3	13.913	A
3	3	13.783	A
4	4	13.783	A
2	4	13.733	A
2	3	13.570	A
4	2	13.493	A
1	3	13.397	A
2	2	13.393	A
4	1	13.377	A
3	2	13.357	A
3	1	13.237	A
2	1	13.237	A
1	4	13.210	A
5	3	13.060	A

1	2	12.923	A
5	2	12.907	A
5	4	12.867	A
5	1	12.790	A
1	1	12.473	A

Alpha 0.01 Standard Error for Comparison 0.7013

Critical Q Value 6.172 Critical Value for Comparison 3.0604

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of TMOISTURE for VARIETIES

VARIETIES	Mean	Homogeneous Groups
4	3.6925	A
3	3.6849	A
2	3.6713	A
1	3.6032	A
5	3.5908	A

Alpha 0.01 Standard Error for Comparison 0.0479

Critical Q Value 4.925 Critical Value for Comparison 0.1670

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of TMOISTURE for INSECTICI

INSECTICI	Mean	Homogeneous Groups
3	3.6779	A
4	3.6752	A
2	3.6329	A
1	3.6082	A

Alpha 0.01 Standard Error for Comparison 0.0429

Critical Q Value 4.695 Critical Value for Comparison 0.1424

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of TMOISTURE for VARIETIES*INSECTICI

VARIETIES	INSECTICI	Mean	Homogeneous Groups
3	4	3.7376	A
4	3	3.7283	A
4	4	3.7125	A
3	3	3.7107	A
2	4	3.7057	A

2	3	3.6828	A
4	2	3.6721	A
2	2	3.6584	A
4	1	3.6573	A
1	3	3.6561	A
3	2	3.6534	A
2	1	3.6382	A
3	1	3.6381	A
1	4	3.6335	A
5	3	3.6115	A
1	2	3.5914	A
5	2	3.5891	A
5	4	3.5869	A
5	1	3.5757	A
1	1	3.5316	A

Alpha 0.01 Standard Error for Comparison 0.0959

Critical Q Value 6.172 Critical Value for Comparison 0.4184

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of SEEDVIGOU for VARIETIES

VARIETIES Mean Homogeneous Groups

1 67.083 A

2 64.833 A

4 62.333 A

3 58.000 A

5 52.917 A

Alpha 0.01 Standard Error for Comparison 9.1895

Critical Q Value 4.925 Critical Value for Comparison 32.005

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of Seed vigour for insecticide.

INSECTICI Mean Homogeneous Groups

1 69.467 A

3 59.533 A

2 58.400 A

4 56.733 A

Alpha 0.01 Standard Error for Comparison 8.2194

Critical Q Value 4.695 Critical Value for Comparison 27.289

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of SEEDVIGOU for VARIETIES*INSECTICI

VARIETIES	INSECTICI	Mean	Homogeneous Groups
1	1	76.667	A
1	3	73.333	A
2	1	73.000	A
4	1	72.667	A
3	1	68.667	A
2	3	67.000	A
4	2	66.000	A
1	2	63.000	A
2	2	59.667	A
2	4	59.667	A
3	2	59.000	A
5	4	58.333	A
5	1	56.333	A
4	4	55.667	A
1	4	55.333	A
4	3	55.000	A
3	4	54.667	A
5	3	52.667	A

3	3	49.667	A
5	2	44.333	A

Alpha 0.01 Standard Error for Comparison 18.379

Critical Q Value 6.172 Critical Value for Comparison 80.208

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of TSEEDVIGO for VARIETIES

VARIETIES	Mean	Homogeneous Groups
1	8.0831	A
2	7.9673	A
4	7.7799	A
3	7.4195	A
5	7.1663	A

Alpha 0.01 Standard Error for Comparison 0.6412

Critical Q Value 4.925 Critical Value for Comparison 2.2331

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of TSEEDVIGO for INSECTICI

INSECTICI	Mean	Homogeneous Groups
1	8.2769	A
2	7.5462	A
3	7.5200	A
4	7.3898	A

Alpha 0.01 Standard Error for Comparison 0.5735

Critical Q Value 4.695 Critical Value for Comparison 1.9040

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of TSEEDVIGO for VARIETIES*INSECTICI

VARIETIES	INSECTICI	Mean	Homogeneous Groups
1	1	8.7277	A
4	1	8.5122	A
2	1	8.5045	A
1	3	8.4968	A
3	1	8.2796	A
2	3	8.0551	A

4	2	8.0496	A
1	2	7.7632	A
2	2	7.6562	A
2	4	7.6534	A
3	2	7.6311	A
5	4	7.5487	A
5	1	7.3605	A
1	4	7.3448	A
4	3	7.2852	A
4	4	7.2728	A
3	4	7.1294	A
5	3	7.1249	A
3	3	6.6380	A
5	2	6.6311	A

Alpha 0.01 Standard Error for Comparison 1.2823

Critical Q Value 6.172 Critical Value for Comparison 5.5962

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of boredseed for VARIETIES

VARIETIES Mean Homogeneous Groups

2 26.000 A

1 22.500 A

3 20.333 A

5 19.500 A

4 18.667 A

Alpha 0.01 Standard Error for Comparison 11.821

Critical Q Value 4.925 Critical Value for Comparison 41.172

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of boredseed for INSECTICI

INSECTICI Mean Homogeneous Groups

4 50.500 A

3 23.833 AB

1 7.767 B

2 3.500 B

Alpha 0.01 Standard Error for Comparison 10.573

Critical Q Value 4.695 Critical Value for Comparison 35.105

Error term used: Error, 40 DF

There are 2 groups (A and B) in which the means

are not significantly different from one another.

Tukey HSD All-Pairwise Comparisons Test of boredseed for VARIETIES*INSECTICI

VARIETIES	INSECTICI	Mean	Homogeneous Groups
2	4	58.500	A
1	4	57.833	A
5	4	47.500	A
3	4	44.500	A
4	4	44.167	A
2	3	37.500	A
3	3	28.500	A
1	1	25.833	A
5	3	25.500	A
4	3	24.167	A
3	2	5.167	A
2	2	4.500	A
4	1	3.833	A
1	3	3.500	A
2	1	3.500	A
3	1	3.167	A

1	2	2.833	A
4	2	2.500	A
5	1	2.500	A
5	2	2.500	A

Alpha 0.01 Standard Error for Comparison 23.643

Critical Q Value 6.172 Critical Value for Comparison 103.18

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of Tboredsee for VARIETIES

VARIETIES	Mean	Homogeneous Groups
2	3.9098	A
3	3.5862	A
1	3.4563	A
4	3.4086	A
5	3.2811	A

Alpha 0.01 Standard Error for Comparison 1.1054

Critical Q Value 4.925 Critical Value for Comparison 3.8498

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of Tboredsee for INSECTICI

INSECTICI	Mean	Homogeneous Groups
4	6.4236	A
3	3.9246	AB
1	2.0169	B
2	1.7486	B

Alpha 0.01 Standard Error for Comparison 0.9887

Critical Q Value 4.695 Critical Value for Comparison 3.2825

Error term used: Error, 40 DF

There are 2 groups (A and B) in which the means

are not significantly different from one another.

Tukey HSD All-Pairwise Comparisons Test of Tboredsee for VARIETIES*INSECTICI

VARIETIES	INSECTICI	Mean	Homogeneous Groups
2	4	6.9086	A
1	4	6.8171	A
4	4	6.1772	A
3	4	6.1101	A

5	4	6.1047	A
2	3	4.9616	A
3	3	4.6205	A
4	3	4.3031	A
5	3	4.0130	A
1	1	3.7170	A
3	2	2.1710	A
2	2	2.0398	A
2	1	1.7294	A
1	3	1.7245	A
4	1	1.6714	A
1	2	1.5664	A
5	1	1.5236	A
4	2	1.4829	A
5	2	1.4829	A
3	1	1.4432	A

Alpha 0.01 Standard Error for Comparison 2.2107

Critical Q Value 6.172 Critical Value for Comparison 9.6478

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of collect for VARIETIES

VARIETIES Mean Homogeneous Groups

1 11.108 A

3 8.886 A

4 8.886 A

5 5.554 A

2 4.443 A

Alpha 0.01 Standard Error for Comparison 4.6742

Critical Q Value 4.925 Critical Value for Comparison 16.279

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of collect for INSECTICI

INSECTICI Mean Homogeneous Groups

4 18.667 A

2 4.441 B

1 3.997 B

3 3.997 B

Alpha 0.01 Standard Error for Comparison 4.1807

Critical Q Value 4.695 Critical Value for Comparison 13.880

Error term used: Error, 40 DF

There are 2 groups (A and B) in which the means

are not significantly different from one another.

Tukey HSD All-Pairwise Comparisons Test of collect for VARIETIES*INSECTICI

VARIETIES	INSECTICI	Mean	Homogeneous Groups
1	4	24.443	A
4	4	22.223	A
3	4	20.000	A
5	4	15.557	A
2	4	11.110	A
1	1	6.663	A
1	2	6.663	A
1	3	6.663	A
3	2	6.663	A
3	1	4.440	A
3	3	4.440	A
4	1	4.440	A
4	2	4.440	A
4	3	4.440	A
2	1	2.220	A
2	2	2.220	A

2	3	2.220	A
5	1	2.220	A
5	2	2.220	A
5	3	2.220	A

Alpha 0.01 Standard Error for Comparison 9.3484

Critical Q Value 6.172 Critical Value for Comparison 40.797

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of Tcollect for VARIETIES

VARIETIES	Mean	Homogeneous Groups
1	2.8494	A
3	2.5796	A
4	2.5383	A
5	1.7127	A
2	1.6251	A

Alpha 0.01 Standard Error for Comparison 0.7713

Critical Q Value 4.925 Critical Value for Comparison 2.6863

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of Tcollect for INSECTICI

INSECTICI	Mean	Homogeneous Groups
4	3.4947	A
2	1.8962	A
1	1.8266	A
3	1.8266	A

Alpha 0.01 Standard Error for Comparison 0.6899

Critical Q Value 4.695 Critical Value for Comparison 2.2904

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of Tcollect for VARIETIES*INSECTICI

VARIETIES	INSECTICI	Mean	Homogeneous Groups
1	4	4.2958	A
4	4	4.0945	A
3	4	3.9120	A
5	4	2.7608	A
2	4	2.4102	A

1	1	2.3673	A
1	2	2.3673	A
1	3	2.3673	A
3	2	2.3673	A
3	1	2.0196	A
3	3	2.0196	A
4	1	2.0196	A
4	2	2.0196	A
4	3	2.0196	A
2	1	1.3633	A
2	2	1.3633	A
2	3	1.3633	A
5	1	1.3633	A
5	2	1.3633	A
5	3	1.3633	A

Alpha 0.01 Standard Error for Comparison 1.5426

Critical Q Value 6.172 Critical Value for Comparison 6.7320

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

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Tukey HSD All-Pairwise Comparisons Test of gleo for VARIETIES

VARIETIES	Mean	Homogeneous Groups
4	11.108	A
1	9.9967	A
3	5.5542	A
2	4.9983	A
5	0.0000	A

Alpha 0.01 Standard Error for Comparison 4.1717

Critical Q Value 4.925 Critical Value for Comparison 14.529

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of gleo for INSECTICI

INSECTICI	Mean	Homogeneous Groups
4	14.221	A
3	4.443	A
2	3.998	A
1	2.664	A

Alpha 0.01 Standard Error for Comparison 3.7313

Critical Q Value 4.695 Critical Value for Comparison 12.388

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of gleo for VARIETIES*INSECTICI

VARIETIES	INSECTICI	Mean	Homogeneous Groups
1	4	26.667	A
4	4	22.220	A
2	4	11.110	A
3	4	11.110	A
4	2	8.8867	A
4	3	8.8867	A
2	3	4.4433	A
3	2	4.4433	A
3	3	4.4433	A
1	1	4.4400	A
1	2	4.4400	A
1	3	4.4400	A
4	1	4.4400	A
2	1	2.2200	A
2	2	2.2200	A
3	1	2.2200	A

5	1	0.0000	A
5	2	0.0000	A
5	3	0.0000	A
5	4	0.0000	A

Alpha 0.01 Standard Error for Comparison 8.3434

Critical Q Value 6.172 Critical Value for Comparison 36.411

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of Tgleo for VARIETIES

VARIETIES	Mean	Homogeneous Groups
4	2.8907	A
1	2.6306	A
3	1.7989	A
2	1.7120	A
5	0.7071	A

Alpha 0.01 Standard Error for Comparison 0.7137

Critical Q Value 4.925 Critical Value for Comparison 2.4857

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of Tgleo for INSECTICI

INSECTICI Mean Homogeneous Groups

4 2.8209 A

3 1.7727 A

2 1.7032 A

1 1.4946 A

Alpha 0.01 Standard Error for Comparison 0.6384

Critical Q Value 4.695 Critical Value for Comparison 2.1194

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of Tgleo for VARIETIES*INSECTICI

VARIETIES	INSECTICI	Mean	Homogeneous Groups
1	4	4.4638	A
4	4	4.1133	A
4	2	2.7149	A
4	3	2.7149	A
2	4	2.4102	A
3	4	2.4102	A

1	1	2.0196	A
1	2	2.0196	A
1	3	2.0196	A
4	1	2.0196	A
2	3	1.7110	A
3	2	1.7110	A
3	3	1.7110	A
2	1	1.3633	A
2	2	1.3633	A
3	1	1.3633	A
5	1	0.7071	A
5	2	0.7071	A
5	3	0.7071	A
5	4	0.7071	A

Alpha 0.01 Standard Error for Comparison 1.4274

Critical Q Value 6.172 Critical Value for Comparison 6.2295

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of pen for VARIETIES

VARIETIES Mean Homogeneous Groups

1 18.886 A

2 17.774 A

5 12.776 A

4 12.220 A

3 5.555 A

Alpha 0.01 Standard Error for Comparison 4.5269

Critical Q Value 4.925 Critical Value for Comparison 15.766

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of pen for INSECTICI

INSECTICI	Mean	Homogeneous Groups
4	30.223	A
2	9.331	B
3	9.331	B
1	4.885	B

Alpha 0.01 Standard Error for Comparison 4.0490

Critical Q Value 4.695 Critical Value for Comparison 13.443

Error term used: Error, 40 DF

There are 2 groups (A and B) in which the means

are not significantly different from one another.

Tukey HSD All-Pairwise Comparisons Test of pen for VARIETIES*INSECTICI

VARIETIES	INSECTICI	Mean	Homogeneous Groups
1	4	42.223	A
2	4	37.777	AB
4	4	28.890	AB
5	4	26.667	AB
3	4	15.557	AB
1	2	13.330	AB
1	3	13.330	AB
2	2	13.330	AB
2	3	13.330	AB
4	3	8.8867	AB
5	2	8.8867	AB
5	3	8.8867	AB
5	1	6.6633	AB
4	2	6.6633	AB
1	1	6.6600	AB
2	1	6.6600	AB
3	2	4.4433	AB
4	1	4.4400	AB

3	3	2.2200	B
3	1	0.0000	B

Alpha 0.01 Standard Error for Comparison 9.0538

Critical Q Value 6.172 Critical Value for Comparison 39.512

Error term used: Error, 40 DF

There are 2 groups (A and B) in which the means

are not significantly different from one another.

Tukey HSD All-Pairwise Comparisons Test of Tpen for VARIETIES

VARIETIES	Mean	Homogeneous Groups
1	4.1614	A
2	4.0589	A
5	3.0689	AB
4	2.9370	AB
3	1.6356	B

Alpha 0.01 Standard Error for Comparison 0.6811

Critical Q Value 4.925 Critical Value for Comparison 2.3720

Error term used: Error, 40 DF

There are 2 groups (A and B) in which the means

are not significantly different from one another.

Tukey HSD All-Pairwise Comparisons Test of Tpen for INSECTICI

INSECTICI	Mean	Homogeneous Groups
4	4.9079	A
2	2.8462	B
3	2.8462	B
1	2.0891	B

Alpha 0.01 Standard Error for Comparison 0.6092

Critical Q Value 4.695 Critical Value for Comparison 2.0224

Error term used: Error, 40 DF

There are 2 groups (A and B) in which the means

are not significantly different from one another.

Tukey HSD All-Pairwise Comparisons Test of Tpen for VARIETIES*INSECTICI

VARIETIES	INSECTICI	Mean	Homogeneous Groups
1	4	6.5320	A
2	4	6.1219	A
4	4	4.6464	A
5	4	4.4783	A
1	2	3.7189	A

1	3	3.7189	A
2	2	3.7189	A
2	3	3.7189	A
3	4	2.7608	A
4	3	2.7149	A
5	2	2.7149	A
5	3	2.7149	A
1	1	2.6758	A
2	1	2.6758	A
4	2	2.3673	A
5	1	2.3673	A
4	1	2.0196	A
3	2	1.7110	A
3	3	1.3633	A
3	1	0.7071	A

Alpha 0.01 Standard Error for Comparison 1.3621

Critical Q Value 6.172 Critical Value for Comparison 5.9444

Error term used: Error, 40 DF

There are no significant pairwise differences among the means.