DECLARATION

I hereby declare that, except for references to other people's work which has been duly cited this work is the result of my own original research and that this work has neither in whole nor in part been presented for degree elsewhere.

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DEDICATION

This work is dedicated to my aunt; Sajo Manga (Deceased),My father, Ebrima Manga who passed away while I was pursuing this programme (R I P), My Mother Sariba Sambou, Step Mother Kombeh Manneh and my wife Mariama Morro Manga and children fatoumatta and Isatou.

ACKNOWLEGEMENTS

First of all, I would like to thank the almighty Allah for his guidance, protection, blessing and strength during this study. I wish to express my sincere appreciation to Dr. Babou Jobe, Director General of the National Agricultural Research Institute (NARI), Dr. M. Ceesay, Deputy Director General and Mr. L. Jobe, Director of Research for nominating me to pursue this programme. I wish to thank Dr. Samba LY, Coordinator of SCARDA and the entire management of CORAF for sponsoring me.

I am indebted to my supervisors; Dr. (MRS) N.S. Olympio and Dr. K. Obeng-Antwi for their guidance, advice and constructive suggestions. You deserved special thanks. My special thanks to professor R. Abaidoo, Provost, College of Agriculture and Natural Resources, Dr. R. Akromah and the entire staff of the Department of Horticulture. My thanks and appreciation goes to the following staff of Crops Research Institute (CRI) for their valuable assistance Messrs: Kankam, Joseph Amponsah, Francis, Edward Abugbilla, C.K Adabre and the entire staff of maize breeding Programme. My appreciations also go to Mr Nyarko and the technicians at the Seed Pathology Laboratory. My appreciations also go to Mr P. Adusei Akowuah of Kwadaso and staffs for their untiring efforts .I wish to extend my gratitude to Dr. B. Banful for his constructive critisms and advice. I wish to thank Mrs Adelaide Agyeman, Biometrician at CRI for her support in the Analysis of my Data.

I acknowledged the encouragement and sincere moral support of Dr. Sait Drammeh, Director General of Agriculture, Mr Ebrima Jow, Head of Seed Technology Programme

and Mr Sulayman Jallow. I am grateful to the entire staff of NARI especially Messrs: A.K. Jarju, Kutubo Sanyang, Mbye Jabang and Falangkoi.

The contributions of the following relatives and friends cannot be forgotten: Yaya Manga, Saikou Fatoumata, Kassi, Saja, Lankamara, Abdoulie, Famara Jaiteh, Matthew, DNA, Mboge, Absa J. Jammeh, Morro Bah and wife, Isatou Jallow Bah, Yanks Sanneh, Bintou Aidara (WAMI) Pateh Bah (WAEC), Sabally, Kan Kalifa,Omar B. Baldeh, Omar Malleh Ceesay, Sutay Jadama, Ebrima Sagnia and family, Eckamboo (Bakary Sanyang), B.S. Secka, E.G Kamara, Eric, Hillary, David, Alhassan Memunatu and all those who contributed in one way or the other in making this work a success.

ABSTRACT

In an attempt to investigate means of minimising storage costs without compromising physiological quality of seed, five (5) maize varieties; namely: *Mamab,. Obatanpa, Kawanzie, Abeleehi* and *Kwadaso Local* were harvested and shelled at moisture levels of 8% and 9% respectively. The maize varieties were packed in moisture-proof polythene bags of 0.2mm thickness and stored under two conditions, the cold room (15°c/85% r.h) and ambient (25°c/70 r.h) for a period of up to five (5) months. Higher germination percentage and vigour were maintained throughout the storage period of five months for seeds stored at 8% moisture level in the cold room. A significant drop in germination percentage and vigour were observed after three months of storage for seeds stored at a moisture content of 9% in the ambient condition. Maize seeds should be dried to a moisture content of 8% and stored under cold condition in order to maintain its high viability and vigour.

Conversely, maize could be dried to a moisture content of 8% and stored under ambient conditions in the absence of cold storage facilities and still maintain an appreciable level of viability and vigour. The study has shown that maize seed dried to a lower moisture content is essential for longevity.

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1.1 Introduction

Maize (Z*ea Mays* L.) originated in America but is now one of the most widely cultivated food crops in the world. It has a remarkably adaptable physiology and is highly described as both 9tropical and a temperate crop. According to Ristanovic (2001), some data suggest that maize was present in Nigeria even before the famous Columbus voyage. Many researchers believe, however, that maize is of recent introduction into Africa compared to Europe and Latin America. Nevertheless, it has become the second staple crop in many countries in Africa and therefore has become very strategic in terms of food security. Maize plays a very important role in Africa's food production.

In east and Southern Africa, it is principally the staple food crop. Although less important in West and Central Africa, it is a major source of energy in these regions, especially in Cote'd'Ivoire, Ghana, Benin, and Nigeria (PROTA 1, 2006).

In the Gambia, maize is the second most important cereal crop after rice and is grown in all the regions of the country. Maize is widely cultivated in the forest and derived savanna zones of Ghana and other African countries. The grain of maize may be white, yellow, purple or reddish in colour. The grain consists of the fruit coat (Pericap) and the seed. The seed itself consists of a seed coat (testa), the germ or embryo and an endosperm. In terms of grain quantities, maize is the most important grain crop in a number of West African Countries. In Ghana, it constitutes one of the major carbohydrates staples in the cities and urban areas, and it is the basic staple food, in the Volta, Greater Accra and Central regions (Tweneboah *et al.,* 2000). Maize is grown in

more diverse regions of the world than any other crop and therefore vast genetic and yield variations exist .Globally maize is ranked second to wheat rice among the world most important crops (Labadarios,2000). Global production of maize exceeds 400 million tonnes per year compared with almost 500 million tonnes of wheat and just less than 400 million tons of rice. Farmers of developed countries grow slightly above 60% of the world production with U.S.A which is the leading producer, producing over 40% on 21 % of the total land area cropped with maize (Ristanovic, 2001). Africa produces about 6% of the world production on 16% of the world total maize land. The average yield of 1.2t/ha in Africa is three times lower than the average for the developed market economies (Ristanovic, 2001).Total maize production in Ghana in 2006 was 1,189,000 tons (FAO, 2007).

The above statistics is a clear indication that maize production is very low in Africa, and for that matter Ghana. Several factors such as lack of improved varieties, low inputs application and poor seed storage conditions may account for this low production (FAO, 2007).

The purpose of seed storage is to ensure that viable seeds that produce vigorous plants are available at planting time. A good seed storage system, therefore should maintain the physiological quality, particularly viability and vigour of seeds. Longevity of seed in storage is controlled primarily by seed moisture content and storage temperature (Asiedu and Powell, 1998). A major cause of poor seed quality is seed ageing or deterioration during storage, particularly at high moisture content. These factors are the major causes

of loss of seed vigour and of viability in the warm and humid tropical environments, such as the humid regions of West and Central Africa (WCA) (Asiedu and Powell, 1998).

In order to prolong storage life of seeds, Seed men often opt for sun or mechanical drying to reduce seed moisture content, followed by storage under low temperature and low relative humidity. The target reduction in temperature and humidity depends on the length of the storage period, the initial viability of the seed, defined seed quality at the end of the storage period as well as the type and value of the seed (van Gastel *et al.*, 1999a).

In many tropical climates ,the average temperature is about 30° C and the relative humidity is often above 75% (Asiedu and Powell, 1998), which means that, using natural air (sun) drying, the equilibrium seed moisture content of maize may not be lower than 11.5% (Asiedu *et al.,* 2001).

By using mechanically heated air blown by fan to dry seed in bins, seed moisture content may be reduced to 11 to 12% (Van Gastel *et al.,* 1999). The rule of thumb for seed storage suggests that 1.0% decrease in seed moisture content or 10°F decrease in storage temperature doubles the storage life of seeds (Harrington, 1972). Thus seed moisture content, which is a function of relative humidity of the storage environment, is more important than temperature in determining storage life.

Farmers usually store their own seeds to maintain viability and avoid losses as well as unpredictable cost. George (1985) reported that temperature and relative humidity are important environmental factors that affect maize during storage. Losses in storage are also partly attributable to the crop and the store conditions (van Gastel *et al.,* (1996). Therefore, to enhance quality and afford some protection for the seed during storage, the seed should be stored at low temperatures and moisture levels (Jelle, 1982).

Crop storage plays an integral part in ensuring domestic food supply. Loss of viability of maize seeds especially quality protein maize (QPM) is a major concern for researchers and other stakeholders. This problem may be associated with poor storage conditions, among others.

As quality is an important characteristic of a crop (Kohl and Uhl, 1998), effective storage is crucial to improve agricultural production and food security for small scale farmers. Maize storage efficiency depends on storage length and losses during storage (including quality deterioration).

The objectives of the study therefore were to:

1. Determine the effect of storage environment on storability of five Maize varieties.
2. Determine the most appropriate Seed moisture content for effective storage and maintenance of Seed viability.

2.0 Literature Review

2.1. Botany of Maize

Maize is a member of the grass family with monoecious flower type in that the male and female flowers are separated but occur on the same plant. Protandry, which is the shedding of pollen before the appearance of the silk and protogyny, which is the maturation of the stigma first are also common with maize (Martin *et al*., 1976). Although maize is capable of self pollination, the plant's monoecious character and protandry ensure cross pollination mostly by wind. Maize is about 90-95% cross-pollinated (Ristanovic 2001). Silk emergence may be delayed by drought and inadequate soil nitrogen (Martin *et al*.; 1976). The female flower is located about midway on the stalk while the male flower is located on top of the plant. In some instances, self pollination may occur in maize especially when there is an overlap of pollen shedding and silk receptivity which creates an ideal condition for self pollination (Martin *et al*., 1976). As a result of this high percentage of cross pollination in maize and its high heterozygosity the maize crop is highly variable. The high variability exhibited by maize has enabled man to select and breed different types of maize, for a wide range of ecological and environmental conditions ranging from the cooler to the dry areas.

The male inflorescence or the tassel is terminal panicle and stretches out from the enclosing leaves at the upper part of the stalk. It is made of branches and these are arranged spirally around the main axis. Flowers are presented with spikelet on the branches. At anthesis the stigma elongates and pollen is released by the anthers. It is estimated that each anther contains 1000- 2500 pollen grains and that each plant is

capable of producing over 10 million pollen grains (Ristanovic, 2001). The female inflorescence called the cob or the ear consist of modified lateral branches arising from the auxiliary lateral branch on the main stem and has compressed internodes whose leaf sheath overlap to cover the internodes as husk. The style, sometimes called the silk, emerges from the husk at the top of the female inflorescence. They are very long and hairy and form the medium for pollen reception.

The maize stalk is herbaceous and varies in height depending on variety and can range between 0.6m-4m. The stalk is sub-divided into internodes which are short at the base and become longer and thicker higher up and tapers towards the male inflorescence. The number of internodes per stalk ranges from 6-20. The stalk is solid throughout and often only one stalk is found per plant, but tillers may be found in few cases.

The leaf consists of the blade, sheath, and the collar-like ligules. All leaves are initiated within the first 4-5 weeks after planting. The leaves are borne alternatively on either side of the stem at the nodes which may be 8-12 in number (Purseglove, 1975).

The radicle of the seed grows to produce the first seminal root after which more seminal roots grow sideways from the embryo. These roots supply most of the nutrients during the first two weeks after germination. They remain functional for some time although later the adventitious roots formed take up the actual task of nutrient absorption.

2.2 Seed Quality of Maize as a factor of production

A uniform stand of healthy, vigorous seedlings is essential if growers are to achieve the yield and quality needed for profitable maize production. Thus, seed quality is critical to growers. According to Spears *et al*. (2002) maize quality can be separated into five related components: germination, vigour, genetic purity, crop purity and health. Of these components, germination and vigour have the greatest impact on seedling emergence and survival. Rapid and uniform germination is as important for better crop production as it is the total germination. In order to get a successful stand establishment high quality seed i.e. maximum germination and vigour must reach farmers.

The Association of Official Seed Analysts (AOSA, 2002) defines germination as an indication of a seed's ability to produce a normal plant under favourable conditions. To a maize grower, germination percentage is the value printed on the seed tag and represents the maximum germination rate of the seed lot if seeds are planted with optimal temperature and soil moisture. However field conditions are rarely optimal and the germination rate may at times over estimate field emergence and seedling survival (AOSA, 2002).It is unusual for maize seed lots to have different seedling emergence and survival rates. Those differences in field performance are often attributed to the physiological quality component known as seed vigour (Spears *et al*., 2002). Seed vigour is defined as "those properties of seeds that determine the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions," (AOSA, 2002) the first count of the standard germination test is considered to be a measure of seed vigour. Its suitability for predicting field emergence of soybean was

discussed by TeKrony and Egli (1977). Generally, vigour tests have proven to be more useful as predictors of field emergence than the standard germination test. When planted in fields with stressed environmental conditions, especially cool and wet conditions, a high vigour seed lot can withstand the stress during germination and early seedling development better than a low vigour seed lot (Spears *et al*., 2002). Thus, emergence is generally higher and seedling growth is more rapid. Vigour tests are used extensively in the seed industry to provide a sensitive, consistent, fast, simple and economic method that can be used to predict the seed performance in the field environment (McDonald, 1980). The (AOSA, 2002) in the Seed vigour testing handbook has included a consideration of the many uses of seed vigour tests. These include company decisions on where to plant and market seeds, as well as seed storage potential. For example, high vigour seed lots may be planted earlier or in the most northern region of America for cultivar adaptation where soils are often cooler. They also retain their quality potential in storage for a longer period of time, and vigour tests can be used to evaluate seed lot carry over potential (Copeland and McDonald, 2001) .The authors also reported that a change of seed chemical composition is one of the factors that may influence the seed germination and vigour.

2.2.1. Factors influencing Seed Vigour

The development of a seed encompasses a series of important ontogenetic stages from fertilization to accumulation of nutrients, to seed dry to dormancy (AOSA, 1999). Each of these stages represents a change in morphological and physiological development that can alter seed performance potential. The point at which the seed achieves its maximum

dry weight is called physiological maturity. At this point, it has its greatest potential for maximum germination and vigour (Delouche, 1974). However, since seeds generally achieve physiological maturity at high moisture levels unsafe for storage, seed is not harvested until it attains harvest maturity, with a low moisture content for safe storage, but high enough to minimize mechanical injury. Between physiological maturity and harvest maturity, the seed is essentially stored on the plant where it may be exposed to severe environmental conditions that adversely affect seed quality (.McDonald, 1980).

2.3 Factors Affecting Longevity

2.3.1. Lifespan of seeds

The lifespan of 'orthodox' seeds, i.e. those of most arable and horticultural species, is a function of time, temperature and moisture content and their longevity can be increased by the reduction of temperature and moisture content (at least to 5%) in store (Cromarty *et al.*, 1982).

2.3.2 Cool dry storage

George, (1980) and James, (1967) reported that modern commercial seed stores are designed with temperature and humidity control facilities largely based on the fact that 'where percentage relative humidity and degrees Fahrenheit total 100 or less, conditions are suitable for seed longevity'. Thus a seed store operating at 50°F (10°C) and 50% relative humidity (RH) will provide suitable storage conditions for prolonging the 'useful' life of temperate orthodox seeds. The term useful life relates to the retention of high viability (germination capacity) and vigour (speed of germination) by seeds over a

commercial storage period which usually falls short of their biological lifespan (George 1980). Seed borne pathogens, particularly those which are not wholly superficial, persist at least as long as the useful life of the seed. Seeds can survive in a viable state from less than 3 years to over 100 years (Bewley and Black, 1994), but in practice most vegetable and cereals seeds are not stored for longer than 3 years in temperate climates. Rice, wheat and maize seeds are stored for less time in the tropics (Neergaard, 1977).

2.3.3 Low temperature storage

Where seeds are retained as a genetic resource, storage facilities are designed to preserve seed viability in the medium term of up to 10 years (stored at 0 – 10°C) or in the long term for at least several decades (stored at sub-zero temperatures) (Cromarty *et al*, 1982). Under such conditions the continuity of certain seed borne organisms may be secured for a considerable period of time.

2.4 Seed Health Testing

2.4.1. Incubation methods

2.4.1.1. Agar testing

The agar test gives an indication of the viable inoculums present in an infected seed sample. This is done by placing seeds onto sterile potato dextrose or malt agar to encourage the growth of seed borne necrotrophs (ISTA, 1999). Plates are incubated at 20°C in the dark for 7 days when the characteristic growth form (mycelium) of the fungus can be identified by eye or using a low or high power microscope. Near-ultraviolet light (NVY) may be used during the last two or three days of incubation to

encourage the development of fruiting bodies (Limonard, 1968). Seeds are spaced on the Petri dishes to avoid cross-contamination. Where there is a considerable outgrowth of fungal saprophytes from the seeds concealing the pathogen or where it is desirable to identify internal infection, seeds may be pre-treated (surface sterilized in 1% free chlorine for 10 min) to free them of superficial microorganisms and then plated onto agar.

There are many variations of the agar test. Acidic agars (e.g. prune lactose yeast) may be used to reduce bacterial contaminants (Maude, 1963); agars may be made semi-selective by the addition of specific chemicals (Kritzman and Netzer, 1978) and/or antibiotics and/or fungicides (Kritzman and Netzer, 1978; Gambogi, 1983; Limonard 1966, Anon., 1993b).

There are standard seed health tests on agar for the detection of Ascocbyta Pisa on pea, Botrytis cinerea on flax and Septoria nodorum on wheat (Anon., 1993). Agar tests are most effective when used for the detection of high-incidence pathogens such as A. pisi and Botrytis allies (onion neck rot) which occur in seed samples at levels greater than 1% and which can be detected by testing 200-400 seeds. Where relationships have been established between the incidence of these fungi in laboratory tests, disease transmission in the field and final infection levels in the harvested crop, the agar test can be used to impose tolerance limits for infection in samples of seed (Anon, 1993).

2.4.1.2. Blotter testing

(Anon., 1993) reported that the blotter test gives an indication of the infection of the seed, as shown by the presence of mycelium and fruiting bodies, and, in some tests, infection of the germinated seedlings as demonstrated by symptoms on the young plants. Standard detection methods vary depending on which fungus is being tested. For example, in phaseolus beans, 400 seeds per sample are placed between water-soaked sheets of paper towelling and incubated for 7 days at 20°C; dark spots on the cotyledons are symptomatic of *Colletotrichum lindemuthianum* infection. In other tests, the germination of seeds is deliberately suppressed to allow seed borne infection to develop (Rao *et al.,* 1984) .Thus brassica seeds (1000 per sample) are placed on blotters irrigated with the herbicide 2, 4-dichlorophenoxyacetic acid (2, 4-D) solution and incubated for 11 days at 20°C in alternating cycles of light and darkness to allow the pycnidia of seed borne *Phoma lingam* to develop. Likewise, carrot seeds (400 per sample) are tested for *Alternaria dauci and A. radicina* on triple-layer blotters soaked in sterile distilled water by incubating them for three days at 20°C, then at -20°C overnight followed by seven days at 20°C in alternating cycles of light and darkness for production of conidia (AOSA,1999).

Deep freezing and 2, 4-D solutions disrupt seed tissues and thereby increase the ease with which seed borne fungi grow from the seeds (Limonard, 1966; Jorgensen, 1977). The germination of seeds is inhibited by 2, 4-D solutions, allowing greater numbers of seeds to be tested (Maguire *et* al., 1978).

Blotter tests are also used for the detection of *Bipolario oryzae*, *Pyricularia oryzae* and *Alternaria padwickii* on rice. The identity of the fruiting bodies of the pathogens (i.e. conidia, pycnidia, etc.) which develop is confirmed by microscope examination. Sterile media including sand, artificial composts, etc. can be used for the detection of certain pathogens. Results are based on the presence of symptoms typical of the organisms.

2.4.2. Storage fungi

Christensen and Kaufman, (1974), reported that the storage fungi of seeds comprise mainly xerotolerant species of the form-genera *Aspergillus* and *penicillium*. This group does not infect seed to any extent prior to storage, but invade only under conditions generally prevailing in the store .In recent years, however, it has become clear that species of the seed storage group may infect maturing grain whist it is still in the parent plant (Hasseltine and Bothast, 1977; Marsh and Payne, 1984; Mclean and Berja k, 1987).

For invasion to occur ,a storage fungus must initially gain access to the seed tissues through some portal of entry .Storage fungi are generally accepted as being opportunistic invaders and saprophytes ,and the pathways of entry into the tissues have been reported as those of being least resistance ;for example ,via wounds in the surface tissue or any natural openings .Christensen and Kaufmann (1974) again reported that maturing seed can be damaged on the parent plant by insects or birds and fungi readily infect such damaged tissues. Mature dry seed is vulnerable to the injury at a variety of stages during its harvest and processing while mites may cause further damage during storage. Further, in maize (for example) the pericarp which covers the entire grain is naturally

discontinuous at only one point ,the micropyle .This natural opening has been reported to provide access to fungi ,thus facilitating invasion of intact ,post harvest grain (Tsurata, *et al*.,1981;Mycock,*et al*.,1988).

However, recent work has shown that propagules of at least some of the storage fungi appear to be present during maize caryopsis (seed) development (Mclean and Berja K, 1987) and that seed harbouring such a fungal infection may carry that infection through into early seedling establishment (Mycock *et al.*, 1988).

3.0 Materials and Methods

3.1 Description of study area

Two field experiments were carried out at CSIR-Crops Research Institute at Fumesua, Kumasi, which is located on latitude 6^0 43'N and 1^0 36'W, and falls within the forest zone of Ghana. This location experiences two rainy seasons, the major wet season which starts from April to mid –July and the minor rainy season from August to November. The soil at Fumesua is classified as ferric acrisol. (FAO/UNESCO legend) with about 5cm thick top layer of dark gritty clay loam. The mean annual rainfall is 1500mm. The mean minimum and maximum temperatures are 21^0C and 31^0C, respectively.

3.2 Study Varieties and their characteristics

The experimental materials used for the study were obtained from Crops Research Institute, Fumesua. These maize varieties were *Obatanpa, Mamaba, Abeleehi, Kawanzie* and *Kwadaso local*. Below are the characteristics of the varieties (Table 3.1)

Table 3.1 Characteristics of the five maize varieties used in the study.

Variety Name	Type	Grain colour/texture	Plant height (cm)	50% silk days	Maturity Days	Average yield(t/ha)
Obatanpa	QPM OPV	W dent	175	55	105	4.6
Mamaba	QPM hybrid	W flint	185	55	110	6.0
Abeleehi	Normal OPV	W dent	157	53	105	4.6
Kawanzie	OPV normal	Y dent	157	53	105	4.6
Kwadaso Local	OPV Normal	W dent	198	59	120	3.0

Source; Maize production Guide (2005); by Food Crops Development Project, CRI, CSIR

OPV = Open-pollinated variety

W = White

Y= Yellow

QPM = Quality protein maize

3.3 Experimental design and cultural practices

The experimental area was ploughed and harrowed to a depth of 20cm. Four improved maize varieties, *Obatanpa*, *Mamaba*, *Abeleehi*, *Kawanzie* and one local check, *Kwadaso local* were planted in April and September, 2009. The experiment was laid out in a randomized complete block design with four replications. Planting was done on $15m^2$ plots at a spacing of 80cm x 40cm.Weeds were controlled by applying gramasol

(paraquat) herbicide at two weeks after planting. NPK fertilizer was applied at planting and Urea at four weeks after planting.

3.4 Field Data collection

The following data were collected:

Days to 50% Seedling emergence – This was determined by counting the number of plants that had 50% days to Seedling emergence per plot..

Days to 50% tasseling- This was assessed by counting the number of days when 50% of the plants from the plots have tasselled.

Days to 50% silking –It was determined by counting the number of days when 50% of the plants in the plots have silk in the ears.

Number of leaves/plant-It was measured by counting the number of leaves on five plants in the two middle rows at 1 and 2 months after planting.

Plant height –This was measured with a metre rule from the ground level to the top of the main shoot on five randomly selected plants on each plot.

Ear height – Ear height was measured from the base of the plant to the node bearing the ear.

Disease Score-Diseases were assessed on a 1-5 Scale. The diseases were Streak, Rust and Blight.

1 = 20% disease observed

2 = 40% disease observed

3 = 60% disease observed

4 = 80% disease observed

5 = 100% disease observed

Days to maturity-This was determined by counting the number of days from planting to harvest maturity when ear leaves were brown and dried.

Yield (kg/ha) - this is calculated by using the following formular; Field weight (kg)/ harvested area x(10,000m/ha)x(100-%grain moisture/85x0.08

3.5 Laboratory Analysis

The experimental design used in the laboratory was 5×2×2 factorial in CRD in four replicates.

The seeds (maize) were packaged in moisture-proof polythene bags 0.2mm thickness for both cold room (15^{o}C) and ambient storage (25^{o}C-30^{o}C) at a moisture content of 8% and 9 % at relative humidity of 85-90% and 70% for cold room and ambient storage, respectively. The experimental design was a completely randomized design and seeds were stored under both conditions. At the end of each month of storage under both conditions, a sample of 100 seeds was obtained in the four replications of each treatment for germination tests. The seeds were germinated in moist, heat sterilized sand (heated at 105^{o}C for 24hrs) in a circular tray (30cm in diameter).Vigour and Germination counts were made on the 4th and 7th day after planting respectively.

3.6 Seed health

A seed health test was conducted for both the ambient and cold storage using blotter method. Ten seeds were plated in each Petri-dish and 20 dishes per sample were incubated at 20^{o}C in alternating cycles of 12 hours light and 12 hours darkness for seven days (Mathur and Kolgsdal, 2003).After 24hrs in the incubation room, seeds were then

kept in the deep freezer at -20°c for at least six hours. Fungi were identified with reference to growth characters using a stereomicroscope and compound microscope .In cases where fungi could not be identified through the stereomicroscope, slides were prepared and compound microscope were used for identification with the help of seed health technicians.

3.7 Data analysis

Data obtained was subjected to analysis of variance (ANOVA) using Genstat Release version 7.2DE and means were separated using least significant differences for field data and Turkeys HSD for laboratory data.

4.0 Results

The climatic data during the growing seasons recorded a higher rainfall in June (533.7mm) and the lowest was recorded in August (20.2mm).High relative humidity was recorded in June(91.0%) and July (90.0% and 90.0%) respectively during the major season.(Table 4.1)

In the minor season, high rainfall was recorded in October (112.6mm) and the least was recorded in December (6.7mm).September and October recorded the highest relative humidity of (88.8%)

Table 4.1 Climatic data during maize growing period in 2009

Month	Temp (^{o} C)		Relative Humidity (%)	Total rainfall (mm)	Rain days
	Min	Max			
Major season					
May	22.9	31.4	86.0	194.5	10
June	22.2	30.0	91.0	533.7	16
July	21.8	28.3	90.6	244.9	11
August	22.1	27.3	90.4	20.2	05
Total				993.3	42
Minor season					
September	22.0	29.2	88.8	69.7	08
October	22.3	31.1	88.8	112.6	14
November	22.2	31.8	86.6	26.3	06
December	22.2	32.9	77.1	6.7	03
Total				215.3	31

Note: The field and Laboratory data below was for only major season. No data was realised during the minor season due to the long drought spelt experienced during the growing season.

4.2 .1. GROWTH AND YIELD OF MAIZE

There was no significant difference among the varieties in terms of days to seedling emergence. Also there was no significant difference in the number of leaves. There was a significant differences (P= 0.05) among the maize varieties in days to 50% tasselling (Table 4.2).*Mamaba* was the earliest to reach mid-tassel and *Kwadaso local* was the longest. There were no significant differences among the varieties in days to mid-silk which averaged 52.7, even though numerically, *Kwadaso Local* was the latest to reach mid-silk. Significant differences between varieties in ear height were observed (Table 4.2) *Kwadaso* local had the highest ear height (104.5cm) and *Mamaba* the least (71.5cm)

Table 4.2: Days to seedling emergence, Number of leaves, Days to 50%tasseling, 50% silking and Ear Height of the five maize varieties

Varieties	Days to seedling emergence	No. of leav	Days to 50% tasseling	Days to 50% silking	Ear ht (cm)
Mamaba	8.25	12.25	47.3	52.3	71.5
Abeleehi	8.00	12.00	48.5	52.5	80.5
Obatanpa	8.50	12.50	48.8	52.5	82.2
Kawanzie	9.25	11.75	49.3	52. 8	88.5
Kwadaso Local	9.75	12.25	49.8	53.5	104.5
Grand Mean	8.75	12.15	48.7	52.7	88.5
Lsd (0.05)	1.31	1.34	0.9	2.0	21.5
CV (%)	7.5	7.2	1.2	2.5	16.3

The reaction of the varieties to the major local maize diseases assessed is presented in (Table 4.3). In general no significant differences were observed among the varieties, for all the diseases.

Table 4.3 Reaction of the Five Maize Varieties to Blight, Rust and Streak

Varieties	% Blight	% Rust	%Streak
Mamaba	1.8	1.75	1.25
Abeleehi	2.3	1.75	1.75
Obatanpa	1.8	1.75	1.50
Kawanzie	1.5	1.50	1.50
Kwadaso local	1.8	1.75	1.50
Grand Mean	1.80	1.70	1.55
Lsd(0.05)	1.2	0.7	0.8
CV (%)	41.8	27.4	33.8

Significant differences were observed between varieties for plant height. *Kwadaso local* had the tallest height (201.2cm)and *Mamaba* recorded the shortest height(168cm) *Kwadaso* local was significantly taller than *Mamaba* and *Abeleehi*.For stem diameter,there was significant difference between varieties. *Abeleehi* was significantly different from *Mamaba* and *Kwadaso* local(Table 4.4)

Table 4.4 Plant heights and stem diameter of five the maize varieties

Varieties	Plant height (cm)	Stem diameter (cm)
Mamaba	168.0	1.8
Abeleehi	172.2	2.2
Obatanpa	198.8	2.0
Kawanzie	181.5	1.9
Kwadaso local	201.2	1.8
Grand Mean	183.8	1.9
Lsd(0.05)	14.7	0.36
CV (%)	5.2	12.03

With the number of plants harvested, there were significant differences observed among the varieties. *Mamaba* was significantly different from *Abeleehi*. Similarly, *Kawanzie* was also significantly different from Abeleehi (Table 4.5). In terms of total number of ears, significant differences were observed between *Mamaba* and *Abeleehi* and *Kwadaso local*. *Mamaba* recorded the highest total number of ears (43.0) *and Kwadaso local* the least (32.8)

With the yield component, there were significant differences between varieties. *Obatanpa* had the highest yield (1339 kg/ha) and *Kwadaso Local* the lowest (877 kg/ha). Moisture content at harvest showed significant differences. *Obatanpa* was significantly different from *Kwadaso local* (Table 4.5)

Table 4.5: No. of Plants Harvested, Total no. of Ears, Yield and Moisture content of the Five Maize Varieties

Varieties	No. of plants Harvested	Total No. of Ears/ Area harvested (7.6m^2)	Yield (kg/ha)	Moisture (%)
Mamaba	44.8	43.0	1236	25.7
Abeleehi	38.0	33.8	1094	27.2
Obatanpa	41.0	36.8	1339	28.5
Kawanzie	45.3	42.0	1139	26.2
Kwadaso Local	39.5	32.8	877	24.5
Grand Mean	41.7	37.6	1137	26.5
Lsd(0.05)	6.7	7.1	214	3.7
CV (%)	10.4	12.2	12.2	9.0

4.3 SEED VIGOUR AND GERMINATION PERCENTAGES DURING STORAGE

4.3.1 One month storage

There was significant difference between varieties for germination percentage after one month of storage. Abeleehi had the highest percentage germination whiles *Mamaba* recorded the least (Table 4.6).Similarly, for vigour percentage, *Abeleehi* produced the highest vigour and *Mamaba* the least. However, no significant difference was observed between storage conditions and moisture content.

Table 4.6 Germination and Vigour Percentages of Five Maize Varieties after one Month of Storage

Varieties	Germination %	Vigour %
Mamaba	93.37	88.37
Obatanpa	96.37	95.50
Kawanzie	95.00	92.25
Abeleehi	97.37	96.25
Kwadaso Local	96.12	95.75
Mean	95.65	93.62
Tukeys HSD(5%)	0.88	0.73
CV(%)	2.62	2.22

4.3.2 Two months storage

There was significant difference between varieties for percentage germination. *Kwadaso local* produced the highest percentage germination, significantly different from *Mamaba*, *Obatanpa*, *Kawanzie* and *Abeleehi*. (Table 4.7). There was significant interaction between storage conditions and moisture content for Maize germination (Table 4.8).Seeds dried to 8% moisture content and stored under cold condition had higher percentage germination than those dried at 9% moisture content and stored under ambient condition..

Table 4.7: Germination percentage of Five Maize Varieties after two months of storage

Varieties	Germination %
Mamaba	89.62
Obatanpa	94.12
Kawanzie	92.00
Abeleehi	96.37
Kwadaso Local	96.87
Mean	93.80
Tukeys HSD(5%)	1.04
CV (%)	3.16

Table 4.8 Effect of moisture content and storage conditions on germination of Maize two months after storage.

	Moisture content		
Storage conditions	8%	9%	Mean
Ambient	92.60	90.80	91.70
Cold	96.50	95.30	95.90
Mean	94.55	93.05	
Tukeys HSD (5%)	Storage= 0.66	Storage x Moisture content=0.93	
	Moisture content=0.66		

There was significant difference in vigour percentage between varieties after two months of storage. *Kwadaso Local* and *Abeleehi* produced the highest vigour whiles *Mamaba* recorded the least(Table 4.9). There was significant interaction between moisture content and storage conditions for maize vigour. Seeds dried to 8% Moisture content and stored under cold condition was significantly different from the ones dried to 9% Moisture content and stored under ambient condition (Table 4.10)

Table 4.9: Vigour percentage of five maize Varieties after two months of storage

Varieties	Vigour %
Mamaba	86.00
Obatanpa	93.62
Kawanzie	91.37
Abeleehi	95.37
Kwadaso Local	96.25
Mean	92.52
Tukeys HSD (5%) 1.18	
CV (%) 3.62	

Table 4.10 Effect of moisture content and storage conditions on vigour of Maize two months after storage

	Moisture content		
Storage conditions	8%	9%	Mean
Ambient	91.80	90.20	91.00
Cold	94.70	93.40	94.05
Mean	93.25	91.80	
Tukeys HSD(5%)	Storage= 0.74		
	Moisture content=0.74	Storage x Moisture content=1.05	

4.3.3 Three month storage

After three month of Storage, there was significant different between varieties for germination percentage. *Abeleehi* and *Kwadaso local* produced the highest germination percentage whiles *Mamaba* recorded the least (Table 4.11).

Significant interaction was observed between storage conditions and the different Moisture content for Maize germination. Seeds dried to a moisture content of 8% and stored under ambient was significantly different from the those dried to a moisture content of 9% and stored under ambient condition. No significant difference was observed between seeds stored at 8% moisture content under cold condition and those stored at 9% moisture content under cold condition (4.12)

Table 4.11: Germination of five maize Varieties after three Months of Storage

Varieties		Germination %
Mamaba		86.62
Obatanpa		93.37
Kawanzie		90.87
Abeleehi		94.25
Kwadaso Local		94.37
Mean		91.90
Tukeys HSD (5%)	1.68	
CV (%)	3.56	

Table 4.12 Effect of moisture content and storage conditions on germination of maize three months after storage

	Moisture content		
Storage conditions	8%	9%	Mean
Ambient	81.10	74.90	78.00
Cold	88.80	87.80	88.30
Mean	84.95	81.35	
Tukeys HSD (5%)	Storage= 1.06		
	Moisture content=1.06	Storage x Moisture content=1.50	

There was significant difference between varieties for percentage vigour. *Kwadaso local* and *Abeleehi* produced the highest vigour, significantly different from *Mamaba*, *Obatanpa* and *Kawanzie*(Table 4.13).There was significant interaction between storage conditions and Moisture content for Maize vigour.(Table 4.14).

Table 4.13: Vigour percentage of Five maize Varieties after three Months of storage

Varieties	Vigour %
Mamaba	85.00
Obatanpa	92.37
Kawanzie	88.62
Abeleehi	93.37
Kwadaso Local	93.75
Mean	90.62
Tukeys HSD(5%)	1.34
CV (%)	4.23

Table 4.14 Effect of moisture content and storage conditions on vigour of Maize three months after storage

	Moisture content		
Storage conditions	8%	9%	Mean
Ambient	89.30	88.10	88.70
Cold	93.70	91.40	92.55
Mean	91.50	89.75	
Tukeys HSD (5%)	Storage= 0.85		
	Moisture content=0.85	Storage x Moisture content=1.21	

4.3.4 Four month storage

After four month of storage, significant differences were observed between varieties for percentage germination (Table 4.15). *Kwadaso* local had the highest percentage germination, significantly different from *Mamaba*, *Obatanpa*, *Kawanzie* and *Abeleehi*. There was significant interaction between Moisture content and storage conditions for germination percentage. Seeds dried to 8% moisture content and stored under cold condition had higher percentage germination than the ones dried at a moisture content of 9% and stored under ambient condition (Table 4.16).

Table 4.15: Germination percentage of Five faize Varieties after Four Month of Storage

Varieties	Germination %
Mamaba	83.25
Obatanpa	90.00
Kawanzie	85.75
Abeleehi	85.75
Kwadaso Local	86.87
Mean	86.32
Tukeys HSD(5%) 1.10	
CV (%) 3.62	

Table 4.16 Effect of moisture content and storage conditions on germination of maize four months after storage

	Moisture content		
Storage conditions	8%	9%	Mean
Ambient	81.00	80.00	80.50
Cold	93.50	90.80	92.15
Mean	87.25	85.40	
Tukeys HSD(5%)	Storage= 0.69		
	Moisture content=0.69	Storage x Moisture content=0.98	

After four month of storage, significant different were observed between varieties for vigour percentage .*Kwadaso local* produced the highest vigour whiles *Mamaba* produced

the least (Table 4.17) Significant interaction between storage conditions and moisture content was observed (4.18).

Table 4.17 Vigour percentage of five maize Varieties after four Months of Storage.

Varieties	Vigour %
Mamaba	81.50
Obatanpa	98.00
Kawanzie	83.12
Abeleehi	85.75
Kwadaso Local	85.87
Mean	85.05
Tukeys HSD(5%)	1.28
CV (%)	4.27

Table 4.18 Effect of moisture content and storage conditions on vigour of maize four months after storage

	Moisture content		
Storage conditions	8%	9%	Mean
Ambient	80.50	79.00	79.75
Cold	91.40	89.30	90.35
Mean	85.95	84.15	
Tukeys HSD(5%)	Storage= 0.81 Moisture content= 0.81	Storage x Moisture content= 1.14	

4.3.5 Five month storage

There was significant difference between varieties after five Months of Storage.*Obatanpa* had the highest germination percentage significantly different from the rest of the varieties (4.19). Similarly, there was significant interaction between storage conditions and moisture content for germination. There was significant interaction between seeds stored at 8% Moisture content under cold condition and the ones stored at 9% moisture content under cold storage (Table 4.20).

Table 4.19: Germination percentage of Five Maize Varieties after Five Months of Storage

Varieties	Germination %
Mamaba	81.00
Obatanpa	88.00
Kawanzie	81.87
Abeleehi	80.87
Kwadaso Local	84.00
Mean	83.15
Tukeys HSD(5%)	1.68
CV (%)	5.73

Table 4.20 Effect of moisture content and storage conditions on Germination of maize five months after storage

	Moisture content		
Storage conditions	8%	9%	Mean
Ambient	81.80	74.90	78.00
Cold	88.80	87.80	88.30
Mean	85.30	81.35	
Tukeys HSD (5%)	Storage= 1.06 Moisture content=1.06	Storage x Moisture content=1.51	

At five month of storage, significant differences were observed between varieties for vigour percentages. *Obatanpa* recorded the highest percentage vigour and *Mamaba* the least (Table 4.21).Significant interaction between storage conditions and moisture content was observed for vigour percentage. Seeds dried to 8% moisture content and stored under cold storage produce higher percentage vigour than those dried at 9% moisture content and stored under ambient condition. (Table 4.22).

Table 4.21: Vigour percentage of Five maize Varieties after five Months of storage

Varieties	Vigour %
Mamaba	78.62
Obatanpa	87.37
Kawanzie	80.12
Abeleehi	80.87
Kwadaso Local	82.50
Mean	81.90
Tukeys HSD(5%)	1.51
CV (%)	5.22

Table 4.22 Effect of moisture content and storage conditions on vigour of maize five months after storage

	Moisture content		
Storage	8%	9%	Mean
Ambient	79.70	73.10	76.40
Cold	87.70	87.10	87.40
Mean	83.70	80.10	
Tukeys HSD(5%)	Storage= 0.95		
	Moisture content= 0.95	Storage x Moisture content= 1.35	

4.4 STORAGE ENVIRONMENT AND VARIETIES ON FUNGAL INCIDENCE

Obatanpa recorded the highest incidence of *Aspergillus flavus* in the ambient storage, but not significantly different from *Abeleehi, Mamaba, Kawanzie* and *Kwadaso* local. The highest incidence of *Aspergillus Niger* was observed also in *Obantanpa*, significantly (p=0.05) different from *Mamaba, Kawanzie, Abeleehi* and *Kwadaso* local. Similarly *Pennicillium spp* and *Fusarium Moniliforme* incidence under ambient storage was also highest in O*batanpa* significantly different from *Mamaba, Kawanzie, Abeleehi* and *Kwadaso* local. There was, however no significant difference between varieties for the incidence of *Botrodiplodia spp. (*Table 4.23*)*

Table 4.23 The percentage incidence of Pathogens of five maize varieties under the ambient storage.

Varieties	*Aspergillus flavus*	*Aspergillus niger*	*Pennicillium spp*	*Fusarium moniliforme*	*Botrodiplodia spp*
Mamaba	21.20	3.35	18.6	2.05	1.00
Obatanpa	30.85	4.20	50.6	2.40	1.05
Kawanzie	19.15	1.60	18.2	1.20	1.10
Abeleehi	28.20	2.80	20.7	1.50	1.05
Kwadaso local	18.55	1.35	20.3	1.65	0.55
Mean	23.59	2.66	25.7	1.76	0.95
Lsd (0.05%)	7.30	0.75	9.91	0.75	1.60
CV (%)	12.1	11.0	15.0	16.7	16.7

Under cold storage *Aspergillus flavus* was significantly difference between varieties. *Obatanpa* recorded the highest incidence, significantly (p=0.05) different from M*amaba, Kawanzie, Abeleehi* and *Kwadaso* local. The highest incidence of *Aspergillus niger* and *Pennicillium spp* were also observed in *Obatanpa*, significantly (p=0.05) different from

Mamaba, *Kawanzie*, *Abeleehi* and *Kwadaso* local. The incidence of F*usaruim Moniliforme* was highest in M*amaba,* significantly different from *Obatanpa*, *Kawanzie, Abeleehi* and *Kwadaso* local. There was, however no significant difference between varieties in the percentage incidence of *Botrodiplodia* in the cold storage condition.

Table 4.24 The percentage incidence of pathogens of five maize varieties in the cold storage.

Varieties	*Aspergillus flavus*	*Aspergillus niger*	*Pennicillium spp*	*Fusarium moniliforme*	*Botrodiplodia spp*
Mamaba	19.10	2.90	17.10	10.1	0.40
Obatanpa	27.10	4.05	40.80	2.3	0.70
Kawanzie	19.00	1.60	17.10	1.2	0.60
Abeleehi	25.15	2.20	18.25	1.3	0.55
Kwadaso local	18.50	1.35	16.60	1.6	0.55
Mean	21.81	2.42	21.97	3.3	0.56
Lsd(0.05)	4.63	0.68	3.37	13.10	0.99
CV (%)	8.3	10.9	6.0	15.5	6.9

5.0 Discussion

5.1 Climatic data during the Growing seasons

The weather data during the growing seasons varied significant in terms of rainfall and relative humidity. The rainfall distribution during the major and minor seasons was quite significant. The highest rainfall during the major season was (533.7mm) and the least was (20.2mm) whereas in the minor season, the highest rainfall recorded was (112.6mm) and the least was (6.7mm).This despararity in the rainfall pattern during the growing seasons caused the low yield of Maize varieties and the delay in other growth components such as days to silking, tasselling as well as the drop in the yield.

The long drought spelt experienced during the minor season (Table4.1) resulted in a very poor harvest and virtually no yield was realised during this growing season in question.

5.2 Vegetative Growth

There were significant differences among the maize varieties in days to 50% tasselling. This may be due to the fact that, the varieties were different in terms of their maturities. *Mamaba* was the earliest to reach mid-tassel. According to the crop production guide (2005) the maximum days for tasselling of *Mamaba* is 55 and could also be earlier if agronomic practices were carried out properly. There was no significant difference with regards to days to 50% silking (Table 4.2).This might be due to the fact that, fertilizer was applied at the right time and plant residues were also available as organic manure. This agrees with the observation by Azontode (1993) who stated that early rains coupled

with required fertilization favours rapid decomposition and release of nutrients from crop residues.

In. Table 4.2, *Kwadaso Local* had the highest ear height (104.5cm). This could be due to the fact it is a local variety and probably has not undergone any formal improvement as have the improved varieties. There was no significant difference with the number of leaves. This was due to the fact adequate agronomic practices were carried out with correct fertilizer application .There was no significant differences among the varieties for their reaction to the major diseases, blight, rust and streak. This means that appropriate agronomic practices were carried out reducing the disease incidence and it is also possible that seed were free of seed bone diseases. (Table 4.3).

In Table 4.5, significant differences were observed within the varieties. *Kwadaso Local* had the highest plant height (201.2cm) whilst *Mamaba* had the shortest (168cm). According to maize production Guide (2005), the maximum plant height of *Mamaba*, *Obatanpa* and *Abeleehi* were 175, 185 and 157 cm, respectively. However all the maize varieties mentioned had heights below the expected mean heights by a large margin probably due to the erratic nature of the rain during the growing season.

5.3 Yield component

Generally, *Obatanpa* (QPM, OPV), *Mamaba* (QPM, hybrid) and *Abeleehi* (Normal OPV) did not attain the potential yield of 4.6, 6.0, and 4.6 tons per ha, respectively according to Maize Production Guide (2005).This drop in the yield margin could be attributed to the short growing season due to erratic nature of rainfall pattern and drought experienced

during growing season. However, *Obatanpa* had the highest yield/ha (1339 kg) whilst *Kwadaso Local* had the lowest yield/ha (877kg).There were no significant differences within the maize varieties in percentage moisture content. However, *Obatanpa* had the highest percentage moisture content (28.5) and *Kwadaso* Local the least (24.5).This was attributed to the fact that *Obatanpa* which had the highest yield/ha among other varieties with high moisture content was also late maturing because the higher the moisture content, the longer the maturity, whilst *Kwadaso* local with the least yield/ha also had the least percentage moisture the percentage and early maturing (Table 4.5)

5.4 Storage

Generally, the results revealed that there were significant differences in germination and vigour percentages among varieties and storage conditions at moisture levels of 8% and 9% throughout the storage period. Seeds dried to 8% moisture content and stored under cold condition had higher germination and vigour percentages than the ones dried to 9% moisture content and stored under ambient condition. However, as the germination and vigour test progressed monthly, cold storage continued to have higher germination and vigour percentages than ambient storage. This could be attributed to the fact that cold storage is in a controlled environment and not subjected to many environmental hazards that might hinder or reduce germination and vigour. Ambient storage was exposed to many environmental hazards such as fluctuating high temperature, insect attacks and other hazards that could reduce its viability and vigour. As germination and vigour tests continued in the last months of storage (4^{th} and 5^{th} months), with moisture contents of 8 and 9%, significant drop was observed in the ambient storage. This was in conformity

with Asiedu *et al.,* (2001) who indicated that seed dried to higher moisture content and stored under ambient conditions lost substantial level of vigour whereas those stored at low moisture and stored in cold room environment maintained its viability and vigour. Harrington (1972) also established the fact that low moisture content and low temperature are important determinants of seed longevity, with moisture content being more important than temperature. The combination of the two factors prolongs the seed storage life than either factor alone.Inspite of the high germination under cold storage, in situations where cold facilities are absent, the results of the study indicated that farmers can still store maize seeds under ambient conditions at 8% moisture content and still maintain a significant proportion of the viability of the seeds.

However, the rule of thumb for seed storage suggests that 1.0% decrease in seed moisture content decrease in storage temperature doubles the storage life of seeds (Harrington 1972).Van gastel *et al* (1999) also indicated that seeds that are dried to very low moisture content and packed in moisture proof bags have very little respiratory activity. Such seed, therefore, loses little energy with no toxic condition build up to cause loss of vigour and viability.

The results from the study clearly indicated that seed deterioration could be minimized by dehumidification to low moisture content. This is in line with Harrington (1972) who indicated that low moisture content and low temperature are important determinants of seed longevity.

Ghawas Bin Maarof (1983) also indicated that apart from the storage environment, some seed characters have also been found to influence storability, such as fruit/seed maturity and seed coat permeability. In Table 4.9, significant differences were observed within the varieties but no significant difference was observed between the two storage methods. *Penicililum* and *Aspergillus* recorded the highest percentage incidence in both storage methods. *Aspergillus* and *penicillium* are both storage fungi and do not infest seed much in storage. This statement is in conformity with Christensen and Kaufmann (1974), who stated that *Aspergillus* and *penicillium* have been reported as not infecting seed to any extent prior to storage, but invading only under the condition generally prevailing in the store. Mclean and Berjak (1987) also mentioned that in recent years, it has become clear that that some seed storage group may infect maturing grains whilst it is still in parent plant.

Mclean and Berja (1987) again indicated that recent work has shown that propagules of at least some of the storage fungi appear to be present during maize caryopsis (seed) development.

6.0 Summary

Seed storage is a major challenge in the tropics. In order to maintain the physiological quality of seed, it should be stored at low moisture content. From the results of the study, it is clear that seed may lose viability quickly when store at high moisture level. However, most the farmers because of ignorance in the seed quality, store their seeds under high moisture level and thus this leads to reduced germination and vigour. Farmers who keep their seeds under low moisture will not encounter any problem of loss of viability within the storage period. High moisture level of seed will cause deterioration and low viability. Seed deterioration which entails physiological ageing and insect and fungi activities, increase with increase in seed moisture content. Seeds dried to 8% moisture content and stored under cold storage condition maintained high Germination and vigour throughout the storage period for all the varieties. However seeds dried to 9% moisture content and stored under ambient condition showed reduced germination and vigour after three months of storage.

6.1 Conclusion and Recommendations

To maintain longevity of seed in storage, it should be put in moisture proof polythene bags (0.2 mm thickness) and stored under low moisture content. This will maintain longevity in storage in both ambient and cold storage methods. The seed stored at 8% moisture content maintained higher germination percentage throughout the storage period in the cold room whereas seed stored at 9% moisture content in the ambient storage showed reduced germination after three months of storage. Thus, it was possible to maintain the physiological quality of maize seed under ambient condition when seed was dried at 8% moisture content and not under higher moisture level. Therefore, there is the need to train farmers on the importance of seed quality thereby encouraging them to dry their seeds to low moisture level in order to maintain viability and vigour or store under cold storage. On the other hand farmers can maintain appreciable viability and vigour with maize dried to 8% and stored under ambient conditions in the absence of cold storage facilities.

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APPENDICES

Appendix 1. Summary of Anova for Germination percentage of five Maize varieties after the one month of storage.

Source	DF	SS	MS	F	P
rep	3	61.000	20.3333		
stor	1	20.000	20.0000	3.19	0.0793
var	4	149.200	37.3000	5.96	0.0004
mc	1	16.200	16.2000	2.59	0.1133
stor*var	4	14.000	3.5000	0.56	0.6934
stor*mc	1	3.200	3.2000	0.51	0.4777
var*mc	4	4.800	1.2000	0.19	0.9418
stor*var*mc	4	4.800	1.2000	0.19	0.9418
Error	57	357.000	6.2632		
Total	79	630.200			
Grand Mean 95.650		CV 2.62			

Appendix 2. Summary of Anova for Vigour percentage of five Maize Varieties after one month of storage.

Source	DF	SS	MS	F	P
rep	3	81.35	27.117		
stor	1	26.45	26.450	6.14	0.0162
var	4	710.00	177.500	41.19	0.0000
mc	1	22.05	22.050	5.12	0.0275
stor*var	4	21.80	5.450	1.26	0.2945
stor*mc	1	2.45	2.450	0.57	0.4540
var*mc	4	2.20	0.550	0.13	0.9718
stor*var*mc	4	0.80	0.200	0.05	0.9958
Error	57	245.65	4.310		
Total	79	1112.75			
Grand Mean 93.625		CV 2.22			

Appendix 3. Summary of Anova for Germination percentage, storage conditions and moisture content of five Maize varieties after two months of storage.

Source	DF	SS	MS	F	P
rep	3	36.40	12.133		
var	4	589.80	147.450	16.76	0.0000
mc	1	45.00	45.000	5.11	0.0276
storage	1	352.80	352.800	40.09	0.0000
var*mc	4	19.00	4.750	0.54	0.7071
var*storage	4	85.20	21.300	2.42	0.0588
mc*storage	1	1.80	1.800	0.20	0.6528
var*mc*storage	4	5.20	1.300	0.15	0.9633
Error	57	501.60	8.800		
Total	79	1636.80			
Grand Mean 93.800		CV 3.16			

Appendix 4. Summary of Anova for Vigour percentage, storage conditions and moisture content of five Maize varieties after two months of storage.

Source	DF	SS	MS	F	P
rep	3	112.95	37.650		
var	4	1073.70	268.425	23.98	0.0000
mc	1	42.05	42.050	3.76	0.0576
storage	1	186.05	186.050	16.62	0.0001
var*mc	4	4.70	1.175	0.10	0.9803
var*storage	4	84.70	21.175	1.89	0.1244
mc*storage	1	0.45	0.450	0.04	0.8418
var*mc*storage	4	7.30	1.825	0.16	0.9562
Error	57	638.05	11.194		
Total	79	2149.95			
Grand Mean 92.525		CV 3.62			

Appendix 5. Summary of Anova for Germination percentage, storage conditions and moisture content of five Maize varieties after three months of storage.

Source	DF	SS	MS	F	P
rep	3	147.60	49.200		
var	4	683.20	170.800	15.95	0.0000
mc	1	45.00	45.000	4.20	0.0450
storage	1	320.00	320.000	29.88	0.0000
var*mc	4	5.00	1.250	0.12	0.9761
var*storage	4	96.00	24.000	2.24	0.0758
mc*storage	1	9.80	9.800	0.92	0.3428
var*mc*storage	4	2.20	0.550	0.05	0.9949
Error	57	610.40	10.709		
Total	79	1919.20			
Grand Mean 91.900		CV 3.56			

Appendix 6. Summary of Anova for Vigour percentage, storage conditions and Moisture content of five Maize varieties after three months of storage.

Source	DF	SS	MS	F	P
rep	3	186.95	62.317		
var	4	896.50	224.125	15.28	0.0000
mc	1	61.25	61.250	4.18	0.0456
storage	1	296.45	296.450	20.21	0.0000
var*mc	4	3.50	0.875	0.06	0.9932
var*storage	4	201.30	50.325	3.43	0.0140
mc*storage	1	6.05	6.050	0.41	0.5233
var*mc*storage	4	4.70	1.175	0.08	0.9881
Error	57	836.05	14.668		
Total	79	2492.75			
Grand Mean 90.625		CV 4.23			

Appendix 7. Summary Anova for Germination percentage, storage conditions and moisture content of five Maize varieties after four months of storage.

Source	DF	SS	MS	F	P
rep	3	85.75	28.58		
var	4	382.80	95.70	9.79	0.0000
mc	1	68.45	68.45	7.00	0.0105
storage	1	2714.45	2714.45	277.66	0.0000
var*mc	4	4.80	1.20	0.12	0.9738
var*storage	4	305.80	76.45	7.82	0.0000
mc*storage	1	14.45	14.45	1.48	0.2291
var*mc*storage	4	5.80	1.45	0.15	0.9630
Error	57	557.25	9.78		
Total	79	4139.55			
Grand Mean 86.325		CV 3.62			

Appendix 8. Summary of Anova for Vigour percentage, storage conditions and moisture content of five Maize varieties after four months of storage.

Source	DF	SS	MS	F	P
rep	3	53.80	17.93		
var	4	529.30	132.33	10.03	0.0000
mc	1	64.80	64.80	4.91	0.0307
storage	1	2247.20	2247.20	170.29	0.0000
var*mc	4	4.70	1.18	0.09	0.9855
var*storage	4	352.30	88.07	6.67	0.0002
mc*storage	1	1.80	1.80	0.14	0.7133
var*mc*storage	4	9.70	2.43	0.18	0.9459
Error	57	752.20	13.20		
Total	79	4015.80			
Grand Mean 85.050		CV 4.27			

Appendix 9. Summary of. Anova for Germination percentage, storage conditions and moisture content of five Maize varieties after five months of storage.

Source	DF	SS	MS	F	P
rep	3	151.00	50.33		
var	4	570.70	142.68	6.29	0.0003
mc	1	259.20	259.20	11.43	0.0013
storage	1	2121.80	2121.80	93.54	0.0000
var*mc	4	31.30	7.83	0.34	0.8464
var*storage	4	157.70	39.43	1.74	0.1542
mc*storage	1	135.20	135.20	5.96	0.0178
var*mc*storage	4	46.30	11.58	0.51	0.7284
Error	57	1293.00	22.68		
Total	79	4766.20			
Grand Mean 83.150		CV 5.73			

Appendix 10. Summary of Anova for Vigour percentage, Storage conditions and Moisture content of five Maize varieties after five months of storage.

Source	DF	SS	MS	F	P
rep	3	68.40	22.80		
var	4	724.20	181.05	9.89	0.0000
mc	1	259.20	259.20	14.16	0.0004
storage	1	2420.00	2420.00	132.18	0.0000
var*mc	4	22.80	5.70	0.31	0.8693
var*storage	4	239.00	59.75	3.26	0.0177
mc*storage	1	180.00	180.00	9.83	0.0027
var*mc*storage	4	26.00	6.50	0.36	0.8395
Error	57	1043.60	18.31		
Total	79	4983.20			
Grand Mean 81.900		CV 5.22			

Appendix 11:Summary of anova for Incidence of *Aspergillus Flavus* in the ambient Storage

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
variety	4	249.574	62.394	7.72	0.023
Residual	5	40.415	8.083		
Total	9	289.989			
LSD(0.05) 7.30					
CV(%) 12.1					

Appendix 12: Summary of anova for the Incidence of *Aspergillus Flavus* in the cold Storage

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
variety	4	134.984	33.746	10.40	0.012
Residual	5	16.225	3.245		
Total	9	151.209			
LSD (0.05) 4.63					
CV(%) 8.3					

Appendix 13:Summary of anova for the incidence *of Aspegillus niger* in the ambient Storage

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
variety	4	11.41400	2.85350	33.18	<.001
Residual	5	0.43000	0.08600		
Total	9	11.84400			
LSD(0.05) 0.75					
CV (%) 11.0					

Apendix 14: Summary of anova for the Incidence *of Aspergillus niger* the cold storage

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
variet	4	0.4100	0.1025	0.25	0.897
Residual	5	2.0350	0.4070		
Total	9	2.4450			
LSD(0.05) 0.68					
CV(%) 10.9					

Appendix 15: Summary of anova for the incidence of *Botrodiplodia* in the ambient Storage

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
variety	4	0.0940	0.0235	0.16	0.952
Residual	5	0.7500	0.1500		
Total	9	0.8440			
LSD(0.05)	1.64				
CV(%)	16.7				

Appendix 16:Summary of anova for the incidence of *Botrodipldia* in the cold Storage

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
variety	4	116.07	29.02	1.12	0.442
Residual	5	129.93	25.99		
Total	9	246.00			
LSD(0.05)	0.99				
CV(%)	6.9				

Appendix 17:Summary of anova for the Incidence of *Fusarium Moniliforme* in the cold Storage

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
variety	4	1.77400	0.44350	5.16	0.051
Residual	5	0.43000	0.08600		
Total	9	2.20400			
LSD(0.05)	13.10				
CV(%)	15.5				

Appendix 18: Summary of anova for the Incidence of *Fusarium Moniliforme* in the ambient Storage

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
variety	4	889.356	222.339	128.89	<.001
Residual	5	8.625	1.725		
Total	9	897.981			
LSD (0.05)	0.75				
CV(5%)	16.7				

Appendix 19: Summary of anova for the Incidence of *Pennicillium* in the cold Storage

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
variety	4	1560.16	390.04	26.27	0.001
Residual	5	74.25	14.85		
Total	9	1634.41			
LSD (0.05)	3.37				
CV(%)	6.0				

Plates

Plate 1: Germination test

Plate 2: Germination Counting

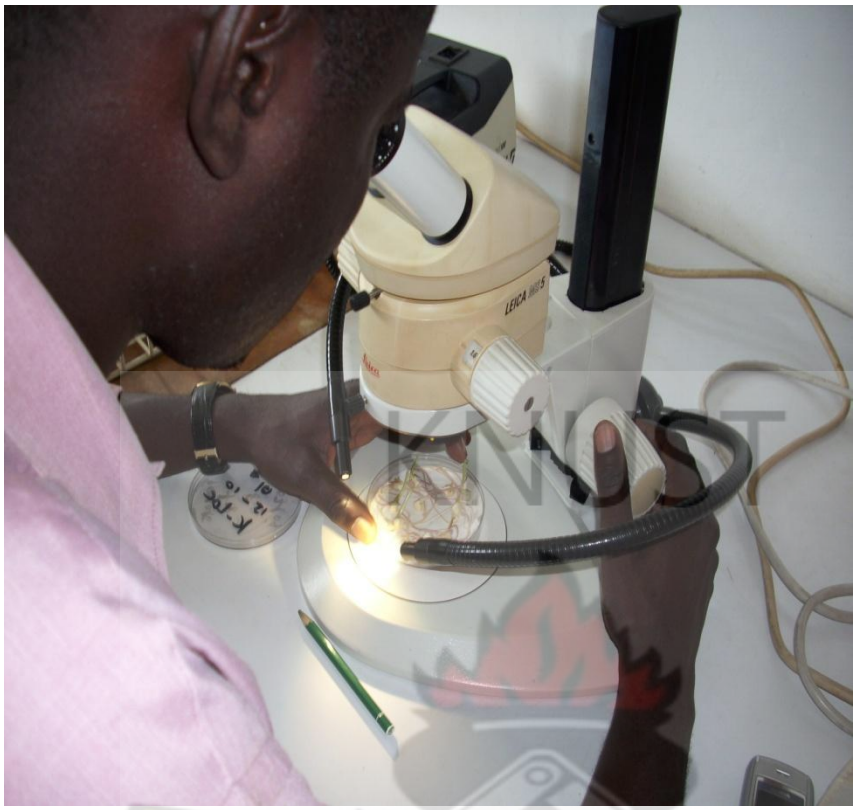

Plate 3: Seeds being Examined for fungi

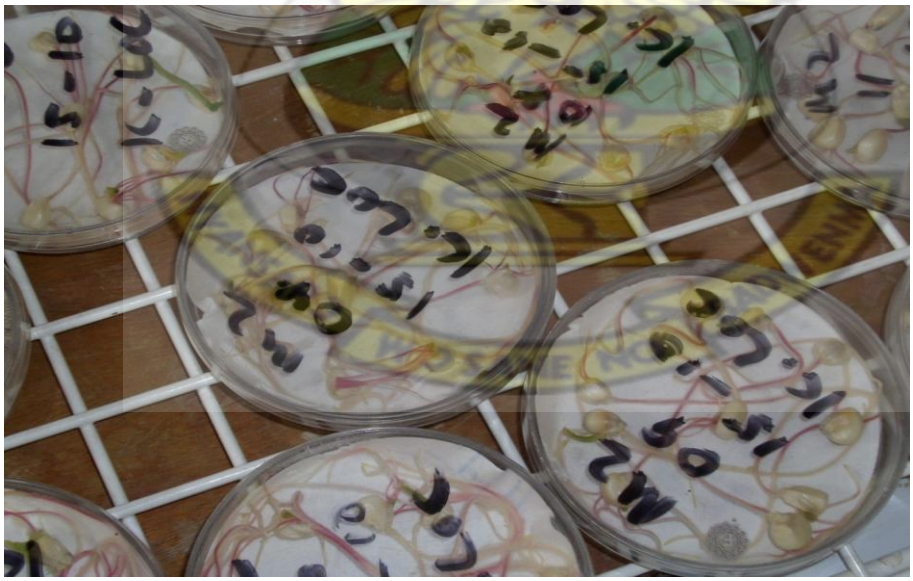

Plate 4: Seeds ready for examination

Plate 3: Maize plants at 50% flowering