KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, GHANA
COLLEGE OF AGRICULTURE AND NATURAL RESOURCES FACULTY OF AGRICULTURE, DEPARTMENT OF HORTICULTURE

ASSESSMENT OF DIFFERENT MATURITY PERIODS AND PROCESSING METHODS ON THE SEED QUALITY OF TWO OKRA VARIETIES

A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF PHILOSOPHY (SEED SCIENCE AND TECHNOLOGY) DEGREE

BY
EDWIN YAW SAKYI

JUNE, 2016

DECLARATION

I, Edwin Yaw **SAKYI**, hereby declare that this thesis submitted in partial fulfilment of M. Phil degree is the result of my personal work, which has not been presented elsewhere for any degree. References to other works have been duly acknowledged.

Edwin Yaw Sakyi	…….	…….
(PG-9010213)	Signature	Date
Dr. B. K. Maalekuu	…….	…….
(Supervisor)	Signature	Date
Mr. P. Kumah	…….	…….
(Co-Supervisor)	Signature	Date
Dr. F. Appiah	…….	…….
(Head of Department)	Signature	Date

ABSTRACT

The field experiment to obtain okra seeds was carried out at Nkwakwa in the Offinso-North District of Ashanti where okra is extensively grown. The Laboratory investigations were done at the Ghana Grains and Legumes Development Board seed laboratory in Kumasi. The experiment was carried out between August 2014 and April 2015. The principal aim of the experiment was to assess the seed quality of two okra varieties harvested at different maturity stages and processed using different methods. Pods were harvested at physiological maturity stages and that of farmers maturity stages. Seeds were later processed using hand shelling of pods and pod pounding in mortar. Seed were further dried to a moisture content of 10% before carrying out the quality investigations. Five aspects of seed quality were investigated and these included purity, vigour, germination percentage, seed fungi and thousand seed weight. At the end of the experiment, it was observed that, okra pods harvested at physiological maturity gave better seed quality than those harvested at the farmers harvest period. The research also revealed that processing of dried pods using hand shelling gave higher seed quality than those processed through pounding in a mortar. For good quality okra seeds in terms of purity, vigour, germination percentage, seed health and thousand seed weight therefore, pods should be harvested at physiological maturity period and processed using hand shelling method.

ACKNOWLEGDEMENT

The success of this research work would not have been possible without the Almighty God. I am therefore most grateful to Him for directing to success a worthy course.

I am highly indebted to my supervisors, first to Dr. B.K Maalekuu and secondly to Mr. P. Kumah both of the Department of Horticulture, Kwame Nkrumah University of Science And Technology (KNUST) Kumasi for their inputs, directions and most importantly the patience that they had for me throughout the writing of this paper.

I am also very grateful to the Head of Department Dr. F. Appiah and all Lecturers and staff of the Horticultural Department who contributed to the success of this paper especially during seminar presentations. I am most grateful to them.

To Dr. R Asuboah of Ghana Grains and Legumes Development Board I say thank you very much for your pieces of advice on my laboratory investigations.

To Mr. Zakari who is doing his national service at the Horticulturel Department of KNUST, Kumasi, I say Allah richly bless you for greatly assisting me to analyze my data.

Finally my sincere thanks go to The West African Agricultural Productivity programme (WAAPP) especially the National coordinator-Ghana, Mrs. Azara Ali Mamshie for sponsoring me to read this programme of Mphil in Seed Science and Technology. I would not also leave out the Ministry of Food and Agriculture for granting me the opportunity to carry out the study. To this ministry I say a big thank you.

DEDICATION

This thesis I dedicate to my family; Rita my wife, Franklin, Godswill, Livingstone and Wisdom my children who through their sacrifices have seen me through this programme. This dedication is also extended to my beloved friend Ramatu for her financial sacrifices that saw me through this programme.

TABLE OF CONTENTS

CONTENT **PAGE**

LIST OF TABLES

TABLE **PAGE**

CHAPTER ONE

1.0 INTRODUCTION

Okra *Abelmoschus esculentus* is a traditional vegetable crop with considerable area under cultivation in Africa and Asia with huge socio-economic potentials in west and central Africa (Kumar *et al*., 2010)

The crop is one of the important vegetables with tremendous nutritional values. The edible portion (fresh fruits) consists of 86.1% moisture, 9.7% carbohydrate, 2.25% protein, 1.0% fibre, 0.2% fat, 9.0% ash in addition to vitamins A, B, C and iodine. (Kochhhar, 1981).

The crop belongs to Malvaceae family. Okra is a warm season crop that is considered to have originated from India (Rao, 1985) and a traditional vegetable crop commercially grown in west Africa, India, South east Asia, the Southern U S A, Brazil, Turkey and northern Australia (Duzyaman, 1997).

There are four known domesticated species of *Abelmoschus,* however *Abelmoschus esculentus* is widely cultivated in South and East Asia, Africa and the Southern U S A (Siemonsma, 1982).

In the Africa context, okra has been called as a perfect villagers vegetable because of its robust nature, dietary fibre and distinct seed protein balance in both lysine and tryptophan amino acids it (unlike the protein of cereal and pulses) provides to diet (NAP, 2006).

The crop mucilage is also suitable for medical and industrial application. It has been used medically as a blood plasma replacement or blood volume expander and also binds cholesterol and bile acid carrying toxic pumped into it by the liver.

To fully achieve the benefits from the consumption of okra, a good quality seed cannot be over emphasized. Kelly (1988) identifies six basic aspects of seed quality, each of which is critical to the success of a crop. These include genetic quality, quality of viability and germination, analytical quality, health quality and physical quality. A healthy seed is thus needed for the desire plant propagation for man to fully benefit from these numerous health potentials of the crop.

Report by ISTA (1979), indicated that seed health is an important factor in the control of crop diseases and further observed that infected seed is less viable, has low germination, reduced vigour and yield. Okra, tomato, hot pepper, maize, wheat and cowpea seeds severely infected with diseases and pest failed to germinate or produced seedlings of high abnormality. The study is therefore critical to the sustainability of the okra industry.

1.1 Problem Statement

Okra is an important vegetable crop in the Offinso North District of Ashanti. It is a prominent income earner for most farm families and provides employment opportunity for the citizens, especially, the youth and women.

Statistics from the District Agricultural Development Unit put the total area under okra cultivation at 554 hectares on block farm bases with over another 50 hectares on scattered holdings (Ministry of Food and Agriculture, 2011).

Farming is a business and thus should be managed from a business perspective with the ultimate aim of maximizing profit. Each operation in the farming process should therefore be carried out in an efficient manner.

However the okra industry is faced with the challenge of good quality seed, culminating into poor seed germination. Germination is the important function of a seed as it is an indicator of its viability and growth (Barua *et al*., 2009).

As an intervention to overcome the problem of poor quality seeds, farmers have resorted to the doubling of the normal Okra seed rate of 4.5kg/ha to over 9.0kg/ha. Apart from the increased production cost, human resources have to be used for refilling of ungerminated gaps which otherwise would have resulted in poor plant population density leading to lower productions, productivity and lower incomes.

To realize the full potentials of the okra industry, there is the need to investigate the possible relationship that is likely to exist between the 2 different maturity stages of harvest and their seed extraction methods that is likely to affect the seed quality and for that matter the quality of germination.

A seed is a living product that must be grown, harvested and processed correctly to maximize its viability and subsequent crop productivity. Good seed can increase yields by 5-10% and assured viability and attain a germination rate of over 80%, good seed vigour and thereby lessoning seed rate (Fact sheet, 2009).

1.2 Justification

The quality of seed planted by farmers is very critical in deciding whether a crop will be good,bad or indifferent (Kelly, 1988). According to the International Seed Testing Association (1993 and 2007) the health of seeds refer primarily to the presence or absence of disease causing organisms such as fungi, bacterial and virus and animal's

pest such as eelworm and insects. The study would therefore help farmers to use good quality seeds void of pest pathogens that cause seed deterioration.

Healthy seeds are the foundation of healthy plant, a necessary condition for good yield (Diaz *et al*., 1998). The above statement depicts the importance of the study which cannot be-over emphasize.

Okra production should be productive with maximizing of profit. Poor quality seeds should not be allowed to deteriorate the production and productivity of the Okra industry and thus the farmer's income.

The research would also help diversify the vegetable industry in the district. Diversification is important in relieving the intense pressure on land use and natural resources (Hughes, 2009). More importantly okra has been considered a minor crop and until recently no attention was paid to its improvement in the international research programme (Duzyaman, 1997). It is therefore very important to carry out the research for the improvement of the okra industry.

The study apart from its benefit to sustain Okra production, it is also in lined with the Ministry of Food and Agriculture policy of providing quality planting materials to farmers, and interventions by researchers and technologies to solve farmer's problems for increased production.

1.3 Objectives

The general objective of the study is the assessment of different maturity periods and processing methods on the seed quality of two okra varieties.

1.3.1 SPECIFIC OBJECTIVES

To conduct seed quality test of purity, vigour, germination, seed weight and health tests for the different maturity stage and processing methods of the Okra varieties.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Concept of Seed and Seed Quality

Seed in Botany is a ripped fertilized Ovules that provides an important means of reproduction, dispersal, and serves as nutrition to seed eating animals and fungi colonies (Wicklow, 1995). However in agriculture seed is defined as any plant part used to regenerate the next generation of a crop (Gardner *et al.*, 1985)

The above definitions depict the importance of seed in agriculture: It is the starting point in agriculture and horticulture, it's source of continuity, change and restoration, as well as it`s important product.

Seed is therefore the basic unit for distribution and maintenance of plant population.

2.2 Seed Quality

Seed quality is complex to defined, but in simple term it is regarded as the degree or standard of excellence in certain characters or attributes that will determine the performance of the seed when sown or stored (Hampton, 2002).In practice the expression seed quality is used loosely to reflect the overall value of seed for it's intended purpose; the performance of the seed must measure up to the expectation of the end user of the seed (Hampton, 2002).According to Copeland and McDonal. 1995 ;Al-Yahya, 2001; Guberac *et al.,* 2003; Simic *et al.,* 2004; Heatherly and Elmore, 2004) if the seed lot possesses high genetic purity and high germination percentage and a minimum of inert materials and other crop seed and are free from diseases it is said to have high quality.

The quality of seeds planted by farmers is all important in deciding whether a crop would be good, bad or indifferent (Kelly 1988). According to Dzomeku and Osei (2005), the yield and sustainability of every crop depends on its planting material base.

The quality of seed has been implicated as a probable cause of low yield (Sinnadurai, 1973 and Horna *et al.,* 2006).

Shetty (2000) indicated that good crop establishment is directly linked to the quality of seed used. Furthermore, Mew *et al.* (1994) reported that the use of good quality seed can lead to a yield increase of 5-20%.

A wider appreciation of the importance of quality seed and their critical role in agricultural and thus human development cannot therefore be over-emphasized (Cromwell *et al.*, 1993; Lanteri and Quagliotti,1997).

Seed quality is most often viewed in the content of genetic trait, germination capacity, analytical purity, physical purity and storage potential (ISTA, 1986). According to ISTA (1986), Quality can be assessed by a range of standardized tests performed on samples taken from seed lot; and then concluded that the reliability of the inferences made about the quality of the seed lot depends primarily on the accuracy with which the sample represents the lot and the precision with which the laboratory tests are performed.

For Kelly (1988), Seed quality aspects each of which is critical to plant growth included, genetic quality, quality of viability and germination, analytical quality, health quality, and physical quality. Kelly (1988) further stipulates that seed need to have good storage quality to ensure that it maintains condition until it is used for

sowing. Simic *et al.* (2007) however viewed seed quality as a multiple criterion that encompasses several important seed attributes: genetic and chemical composition, physical condition, germination and vigour, seed size, seed moisture content, physical appearance as well as presence of seed-borne pathogens or weed and crop contaminants.

For Ellis. (1991) seed quality is rather a broad term which encompasses several factors including seed health, varietal and physical purity, germination, vigour and size (or weight).

Seed quality is therefore critical to crop establishment, and for that matter production and productivity.

2.2.1 Seed Purity

The purity of a seed lot can be viewed from two angles; Genetic and physical. Genetic purity of seed refers to the trueness to type while physical purity of a seed lot refers to the physical composition of the seed (Anonymous,2009).The pure seed component of a seed lot together with seed germination capacity are used to determine the planting value of the seed (Rindels, 1995).

2.3 Assessment of Aspects of Seed Quality

The aspect of seed quality parameters been most often given prominence by ISTA rules and standards include: physical purity, germination percentage, analytical purity, vigour and seed health. However among these aspects seed health testing currently suffers limited application, whilst germination potential is perhaps the most important

quality parameter used to determine sowing rates, time of sowing or whether the seed can be stored (Tanaka, 1984; Basu, 1995).

As stipulated by Mathur and Kongsdal (2003) sowing of high quality seed is essential for improving crop yield and increasing food production. This depicts the fact that assessing the quality of seed before sowing is very essential for farmers.

2.3.1 Seed Germination

Germination according to Gardner et al (1985) and Hadidi (1996) is the resumption of active growth of the embryo initiated when the seed is subjected to favourable environmental conditions of moisture, temperature and oxygen. ISTA (1993, 2007); Copeland and McDonald (1995); Madsen (1988) and Mathur *et al.* (2003) all defined germination as the emergence and development of the seedlings to a stage where aspects of its essential structures indicate whether or not it is able to develop further into a satisfactory plant under favourable conditions in the soil.

Germination conducted on nursery bed is usually slower and less complete than laboratory germination (Tanaka 1984). Tanaka (1984) further stated three methods by which germination is expressed and which included; Mathematical values based on standard laboratory test result, germination under stressful conditions, and biochemical testing. Basu (1990) reported that it is difficult to maintain germination capacity or the potential viability of seed especially in hot climates and acknowledged that germination results remain the prerequisite for assessing seed for planting or industrial purposes

2.3.1.1 Types of Germination

Hadidi (1996) and ISTA (1979) identified two types of germination; epigeal (exhibited by most dicotyledons) and hypogeal type of germination (exhibited by most monocotyledons) occur among horticultural crops and woody plants. Gardner *et al.* (1985) also documented the two types of germination and explained that in hypogeal type of germination the cotyledons remain under the soil but are pushed out in the case of epigeal type of germination as the epicotyl and hypocotyl elongate. Schmidt (2000) recommends the epigeal and hypogeal types of germinations and concluded that epigeal type of germination is by far the most common in woody plants.

Schmidt (2000) further recognized two intermediate types of germination; the semi-hypogeal in which the hypocotyl does not elongate but the cotyledons emerge and the second type been the durian type in which the hypocotyl elongate but the cotyledons do not emerge.

2.3.2 Factors Influencing Germination

Several factors affect seed germination. These factors can basically be put into two major group; biotic and abiotic factors. These factors include temperature, seed moisture, light, air, humidity, plant pathogens, mechanical damage and insects or mite among others. Among these factors, Copeland and McDonald (1995) documented that temperature, water, oxygen and light are the important external factors or conditions necessary for seed germination.

2.3.2.1 Influence of Seed Moisture Content on Germination

Seed quality is reported to have been affected by high seed moisture content. At moisture content of between 40%-60% moisture content, metabolic activities increased and seed germination is catalyzed, resulting in the death of the embryo. As reported by Cantliffe (1998) seeds with hard seed coat prevent oxygen and moisture entry into the seed and prevent autoxidation of linoleic and linolenic acids which are responsible for degradation of cellular organelles.

2.3.2.2 Effect of Temperature on Germination

Temperature is required for germination of non-dormant seeds (Gardner *et al.*, 1985). Driscoll (1990) reported that high temperatures during seed maturation may induce dormancy in seeds. Some seeds require vernalization before they can germinate, grow and initiate flowers. Driscoll (1990) further observed that winter wheat seed requires 2°C treatment for six weeks before planting to induce flowering.

Copeland and McDonald (1995) also observed that temperature as well as water, oxygen and light are important external factors necessary for seed germination. However as stipulated by Gardner *et al.* (1985), Copeland and McDonald (1995) most tropical seeds are very sensitive to chilling during germination especially at temperatures below 10°C.

To Simic *et al.* (2007) the combine effect of high temperature and relative humidity accelerate seed deterioration independent of the initial seed quality.

2.2.3.3 Influence of Fungi Pathogen on Seed Germination

Wu and Cheng (1990) documented that seed borne pathogens are major factors which reduces seed vigour and listed *Curvularia lunata, Drechslera maydis* and *Fusarium moniliforme* as the most prominent ones attacking Sorghum seed.

FAO (1981) also noted that disease pathogens are sometimes responsible for loss of germination in seeds. Wicklow (1995) similar reported that under commercial grain storage, fungi are the primary cause of seed deterioration which is depicted by loss of germination, decrease in dry matter, increase in acidity, gain heating and ultimate sprouting.

Mathur *et al.* (2003) also documented that seed –borne fungi that are capable of producing symptoms on young seedlings or even cause death are species of *Alternaria, Ascochyta, Fusarium, Bipolaris, Colletotrichum, Macrophomina* and *Pyricularia*.

To Neergaad (1979) many of the seed-borne fungi associated with cowpeas reduced seed germination and produced symptoms on infected seedlings. Maloy (1993) also stipulated that black stem caused by *phoma medicaginis* could kill young seedlings sown after germination, but loose smuts of cereals may remain latent and show only when the plants matured, resulting in low seed vigour.

2.2.3.4 Influence of Seed Weight on Seed Quality

Thousand seed weight is one of the important scales of seed quality that influences on germination, seed vigour, seedling establishment and yield (Moshatati and Ghariueh, 2012). As documented by Moshatati and Ghariueh (2012), though factors such as Genetic structure, environment and parental nutrition, maturity stage in harvest time,

mechanical damage among others affect seed germination and vigour, thousand seed weight is one of the important scales in seed quality. High thousand seed weight would increase germination percentage, seedling emergence, tillering, spike and yield (Noor Mohammadi *et al*; 2000: Cordazzo, 2002).Gorge and Ray (2004) showed that with increasing in hundred grain weight of parthenium argentatum L. increase the germination percentage.

Khan (2003) documented that with increase in seed weight of Artocarpos heterophyllus L. from 4.6g to 12-14g the germination percentage increased from about 15% to about 85%. Malcolm *el al*. (2003) noted that with increased in seed weight and seed size of peach rootstock increased the germination seed percentage.

2.4 Effect of Seed Vigour on Seed Quality

Assessment of the ability of seed to germinate is a common test for seed quality.

The definition and determination of seed vigour has been problematic unlike those for germination and seed size (weight) (Ellis, 1991).

Seed vigour can be defined as the sum total of those properties which determine the potential level of activity and performance of the seed lot during germination and seedling performance (Mathew and Powell, 1995: Byrum and Copeland, 1995). However, Cantliffe (1998) defined vigour as the ability of the seed to germinate rapidly and produce normal seedling under a wide range of condition.

On the other hand Delouche (1974) documented that seed vigour is a concept describing several characteristics associated with the rate and uniformity of seed germination and emergence as well as seedling growth.

Seed vigour is not a sample measurable property, but rather a qualitative character controlled by several factors that affect the germinating seeds (Hamptom and Coolbear, 1990). Due to variations in vigour, seed lot with similar germination may respond differently when subjected to adverse field conditions. Powell and Mathew (1995) also documented that seed vigour differs among many species due to ageing and accumulation of degenerative changes that culminate in the death or failure of the seed to germinate. As reported by Bishaw and Van Gastel (1993), Seed vigour can be affected by mechanical damage to the seed coat or the embryo, stage of maturity at harvest, seed size, senescence, attack by pathogens and drying temperature. Tomer and Maguire (1990) observed that low vigour may be due to genetic, physiological, cytological, mechanical and microbial factors.

2.4.1 Effect of Seed Health on Seed Quality

ISTA (1979) stated that seed health is an important factor in the control of crop disease and further observed that infected seed is less viable, has low germination, reduced vigour and reduced yield. Okra, tomato, hot pepper, maize, wheat and cowpea seeds severely infected with diseases and pest failed to germinate or produced high percentage abnormal seedlings (ISTA, 1979). Seed health testing in recent times, has become an integral part of seed quality assessment. The health of seed according to ISTA (1993, 2007) refers primary to the presence or absence of disease-causing organism, such as fungi, bacteria, and viruses, and Animal pests such as eel worms and insects, but physiological conditions such as trace element deficiency may be involved.

Seed health status is also affected by the presence of non- disease causing contaminants in a particular seed lot (Mew and Gonzales, 2002).This contaminants

according to (Mew and Gonzales, 2002) include weed seeds that compete with the target seeds for nutrients, other seeds, plant parts other than the target seeds, soil particles and insect eggs that can degrade the quality of the seed lot.

As reported by Diekman (1996) any part of a plant is subjected to a disease, which may occur at any stage: seed, seedling, growing plants among others. FAO (1981) emphasized by giving a list of fungi associated with seeds which may cause disease as *Aspergillus spp*., *Botyrodiplodia theobromae, Cladosporium spp., Curvularia pennisetium, Dreschera maydis, D. oryzae, D. Setariae, Fusarium spp.,Pennicillium spp., Phoma exigua,* and *Trichoconiella padkii*. Agarwal (1995) however, reported that seed-borne microflora associated with seed does not necessarily result in disease condition but may rather enhance seed protection. He further observed that in oryzopsis maleacea, seed dormancy was broken by the invasion of *Pennicillium funiculasum* on the seed palea and lemma, thereby improving germination.

Hewett (1981) has pointed out that there are differences in the way in which a pest or disease spread. According to the author, some pathogens are relatively uncomplicated being dependent on the host crop.

Plants are only able to spread infection when conditions are favourable. Others can exist on various plant or crop residues as well as the host crop plant and are usually difficult to control since they are capable of reinfecting a crop which has been treated successfully against the pathogen.

Several methods of identifying seeds-associated with fungi have been reviewed by many scientists and included inspection of dry seed, washing test, blotter method, embryo count, seedling symptom test, agar plate method and polymerase chain reaction among others. Neergaard, 1979; (Mathur and Kongsdal 2003). Maude,

(1988) reported that seeds high in purity and germination but infected with seed-borne pathogens is of low planting value.

Morre and Tymowski (2005) also reported that when seeds are used for sowing, seeds-borne pathogens may cause disease or death of plants resulting in crop loss.

Juidal and Thind (1990) also documented that *Pennicillium acidovorans* and *Fusarium semitectum* were found to be associated with shrivelled of cowpea.

Furthermore, effect of seed-borne pathogens on plants health vary widely. Some pathogens such as *Gloeotinia temulata,*which cause blind seed in fescue, kill the seeds as they develop. Others such as *phoma medicaginis*, the causal agent of spring black stem in Alfafa has great propensity to kill the seedling (Maloy, 1993). Neergaard, (1979) also pointed out that the seed can serve as a vehicle for the dissemination of plant pathogens when they bear inoculum which can result in disease outbreak through infection in the endosperm or embryo.

2.5 Seed Dormancy

The seed coat protects the internal parts of the seed during a period called dormancy, prior to germination. Madsen (1988) defined dormancy as the state in which seeds will not germinate despite favourable external conditions which may be due to endogenous or exogenous factors. However, Opeke (1982) identifies mechanical or internal physiological barriers to seed germination due to imposed dormancy. Opeke (1982) further observed that lack of dormancy in cacao and citrus makes them exhibit vivipary and tend to make them sensitive to temperatures as they lose viability with long storage

CHAPTER THREE

3.0 MATERIALS AND METHODS

The field experiment was carried out in Nkwaakwa in the Offinso-North District of Ashanti where okra is extensively produced. However, laboratory investigations of seed quality aspects were done at the seed laboratory of the Ghana Grains and Legumes Development Board in Kumasi.

3.1 Experimental Design and Field Planting

The field design was that of Randomized Complete Block Design. This was planted with seeds of two okra varieties in four replicates. Seeds were sown at a spacing of 80cm between rows and 60cm within hills (personal communication). There was four blocks with each consisting of two plots, each measuring 1.6m by 21m. There were three rows in each plot with 35 hills of seed in each row. The total experimental area was thus 19m by 21m.

3.2 Cultural Operations

Agronomic practices carried out included weed control, thinning, fertilizer application and pest control.

3.2.1 Harvesting

Pod harvesting was done at two maturity stages. The first harvest was done at the physiological maturity stage, whilst the second harvest was done at the farmers maturity stage.

Harvesting at physiological maturity stage was determined by the method prescribed by House (1985) and Chopra (1982). That is when the seed moisture is between 25 –

30%. At this stage the seed are still soft and so were further dried to a moisture content of 10%.

Physiological maturity of crops was also determined by the physical appearance of the crop. This is where the colour of the crop turns from green to brown (Kelly, 1988).

On the other hand, the farmer's maturity stage is when the green fruit turns dark brown or black. (Personal communication)

3.3 Seed Processing

The pods after harvest were further dried to a moisture content level of 10%.The Seeds were then extracted using hand shelling and pod pounding in mortar.

3.4 Seed Quality Analysis

Seed quality analysis conducted included, seed analytical purity, vigour, germination, thousand seed weight and health.

3.4.1 Analytical Quality Analysis

Samples from the two seed varieties and their various maturity stage of harvest were taken through analytical purity test. The seeds were separated into three categories according to ISTA (2007) procedure. These categories included

a. Pure seeds
b. Other crop seeds and
c. Inert materials.

These various components were weighed after separation and their percentages by weight calculated .

3.4.2 Seed Vigour Test

Vigour test was measured as the percentage of germinated seeds by the 4th day after seeding otherwise known as speed of germination as defined by Cantliffe (1998). Data for the germinated seeds on the fourth day were gathered for each seed sample and their averages taken.

3.4.3 Germination Test

Germination test was conducted using river sand in a germination pan. Four hundred seeds as suggested by AOSA (1981) were taken from each seed sample for the test. Each seed pan contained two replicates of 100 seeds. Two pans each were thus used for each seed sample. For uniformity in placing the seeds in the soil, a counting box was used. Each seed pan was adequately watered, covered with additional pan and arranged on a shelf. The soil was kept moist by routine watering as suggested by Agrawal (1995).

Germination count started from the fourth day and lasted for 14 days. The results were calculated as normal, abnormal and dead seedlings in percentages.

3.4.4 Thousand (1000) Seed Weight

Seeds from the two maturity stage of harvest and processing methods were counted in eight replicates of hundred seed and weighed (ISTA 2007). From the eight replicate weight of 100 seeds, the average weight of 1000 seeds was calculated from the formula (10 x μ), as suggested by ISTA (1993).

The variance, standard deviation and coefficient of variation were calculated according to the formula:

Variance= N (∑X)-(∑X)/N (N-1)

Where X= weight of each replicate in grams

N= Number of replicates

Standard deviation=√ Variance

Coefficient of Variation= S/μ+100

Where μ= Mean weight of 100 seeds

3.4.5 Seed Health Test

The seed health test was done using the Blotter method (Marthur and Kongsdal, 2003). Two hundred seeds were randomly taken from the pure seed of each sample for the health test. Twenty-five seeds each were placed on a moistened filter paper per petri ditch and incubated for 7 days at 22 degree Celsius under 25 hours of alternating cycles of light and darkness. After incubation, the seeds were examined under stereo binocular microscope to determine any incidence of fungi and fruiting bodies.

3.5 Seed Moisture Content

The moisture content of the pure seed samples at both physiological maturity and farmers harvest maturity were determined before drying them to a moisture content of 10%. The seed moisture content were determined using of an electronic moisture meter which was calibrated by the oven dry method before usage. This was done in four replicates of 25g of each seed sample.

3.6 Analysis of Data

Genstat Statistical Package was used to analyse the data. Means were separated using Duncan's multiple test at P=0.01.

CHAPTER FOUR

4.0 RESULTS

4.1 Effect of okra varietal differences on some seed quality parameters

Two varietal differences of okra on some seed quality parameters is presented in table 4.1. Asha okra variety showed significant differences over Asontem variety in the seed quality parameters of germination and purity, whereas the Asontem variety showed significant difference in thousand seed weight. There was however no significant difference in the quality parametres of vigour between the Asha and Asontem okra varieties.

Table 4.1 Effect of okra varietal differences on some seed quality parameters.

Source of variation	Purity%(wt)	Vigour %	Germination%	Seed wt.(g)
Asha	92.84a	35.81a	79.22a	46.56b
Asontem	91.52b	37.06a	72.09b	47.26a

$P \leq 0.01$

Mean with the same letter are not significantly different.

4.2 Effect of variety by maturity stage interaction on some seed quality parameters of okra.

Table 4.2 represents the effect of variety by maturity stage interaction of okra on some seed quality parameters. In terms of seed purity Asha showed no significant difference over Asontem when both crops are harvested at physiological maturity stage ($P > 0.01$). However purer seeds are statistically recorded for Asha variety over Asontem variety when both crops are harvested at the farmer's maturity stage.

So also was Asha at physiological maturity significantly purer in seeds over Asontem at farmer's maturity.

The result for the interaction effect of the Asha and the Asontem okra varieties showed no significant difference for seed vigour when both crops are harvested at physiological maturity stage. Similarly, no statistical difference was recorded by Asha over Asontem when both are harvested at the farmer's maturity stage. However Asha showed a significant difference in seed vigour when harvested at the physiological maturity stage than at the farmer's maturity stage. Also was Asontem variety showed a significant difference in seed vigour when harvested at physiological maturity stage over when harvested at the farmer's maturity stage.

In terms of seed germination percentage, Asha differed significantly over Asontem variety when both are harvested at the physiological maturity stage ($P \leq 0.01$). When both varieties are harvested at the farmer's maturity stage Asha once again showed a statistical difference in germination percentage over Asontem variety. Asha variety when harvested at physiological stage differ significantly in germination percentage over when harvested at the farmer's maturity stage. Similarly Asontem also gave a statistical difference in germination percentage over when it is harvested at the farmer's maturity stage ($P \leq 0.01$).

In the aspect of seed weight, heavier statistical seed weight is recorded by Asha okra variety over the Asontem when both crops are harvested at the physiological maturity stage. So also is the Asha variety significantly heavier in seed weight over Asontem when they are both harvested at the farmer's maturity stage. On the other hand Asha is statistically heavier in seed weight when harvesting is done at the physiological maturity stage over when harvesting is effected at the farmer's maturity stage. In the

same way Asontem is significantly heavier in seed weight when harvested at the physiological maturity stage over when harvested at the farmer's maturity stage P ≤ 0.01%

Table 4.2 Effect of variety by maturity stage interaction on some seed quality parameters of okra.

Source of variation	Purity (% wt)	Vigour (%)	Germination (%)	Seed weight (g)
Asha * Physiological	95.35a	48.69a	81.60a	49.78a
Asontem * Physiological	94.88a	45.65ab	75.03b	49.25b
Asha * Farmer's maturity	90.33b	22.94c	76.84b	43.33d
Asontem * Farmer's maturity	88.17c	28.47bc	69.17c	45.27c

P ≤ 0.01

Mean with the same letter are not significantly different.

4.3 Interaction effect of variety by seed processing methods and maturity stages of okra on some seed quality parameters.

The interaction effect of variety by seed processing methods and maturity stages of okra is presented in Table 4.3. Asha okra variety processed using hand shelling method when harvested at the physiologically matured stage produced significantly purer seeds over those processed through the pod pounding method but harvested at the same physiological matured stage.

Similarly Asontem variety when processed using the hand shelling method at the harvesting of physiologically matured stage gave significantly purer seeds in

percentage by weight over when processed by the pod pounding method that was harvested at the same physiologically matured stage ($P \leq 0.01$)

Again, the Asontem variety when processed by the hand shelling method at the harvesting of the farmer's maturity stage differed significantly in purer seeds in percentage by weight over when processed using the pod pounding method but at the stage of maturity

Similarly, Asha variety when processed using the hand shelling method but harvested at the farmer's matured stage recorded significantly purer seeds over when the same Asha is processed using pod pounding method but harvested at the same farmer's maturity stage. ($P \leq 0.01$)

However, when Asha variety processed through pod pounding and harvested at physiological maturity stage was compared with Asontem processed through pod pounding and harvested at the same physiological maturity stage, the result gave no significant difference in seed purity ($P \geq 0.01$).

Similarly, there was no significant difference in seed purity when Asha processed through hand shelling and harvested at the physiological maturity stage is compared with Asontem processed through the same hand shelling and at the harvesting of physiological maturity stage.

However, Asha gave statistically purer seeds when processed using hand shelling and harvested at farmer's maturity stage over Asontem variety processed through the same hand shelling method and the same harvesting stage of farmer's maturity.

In the same way Asha processed through pod pounding with harvesting at the farmer's maturity stage recorded significantly purer seeds in percentage by weight

over Asontem variety processed through pod pounding and at the harvest of farmer's maturity stage ($P \leq 0.01$)

There was no significant different in seed vigour for Asha variety processed through pod pounding when harvested at physiological maturity stage over Asha processed through hand shelling and harvested at the same physiological stage ($P \geq 0.01$).

Similarly, no significant different in seed vigour (in percentage) was recorded for Asontem processed through pod pounding when harvested at physiological maturity over Asontem variety processed through hand shelling and at the harvest of same physiological maturity stage.

Similar results were recorded for Asontem at hand shelling and farmer's maturity stage over same Asontem at pod pounding and farmer's maturity stage ($P \geq 0.01$).

The same result of no significant difference in seed vigour was recorded for Asha at the farmers' maturity stage with hand shelling over same Asha or pod pounding and at farmer's maturity stage ($P \geq 0.01$).

However, when Asha was processed using the hand shelling method for okra harvested at physiological maturity stage was compared with the same Asha processed through hand shelling method and at the harvest of farmer's maturity stage, the former proved significantly different in seed vigour ($P \leq 0.01$).

For seed germination, Asha okra variety processed using the hand with harvesting at the physiological maturity stage gave significant difference in seed germination percentage over Asha processed through pod pounding but harvested at the same physiological maturity stage ($P \leq 0.01$).

Similarly, Asontem when processed using the hand shelling method with harvesting at the physiological maturity differ significantly in germination percentage over same Asontem processed through pod pounding with harvesting at the same physiological maturity stage ($P \leq 0.01$).

Conversely, there was no significant difference in germination percentage of Asontem processed by hand at the harvesting of farmer's maturity stage over same Asontem variety processed through pod pounding with the same harvesting at the farmer's maturity stage ($P \geq 0.01$).

However Asha processed through hand shelling at the harvest of farmer's maturity stage recorded significant difference in germination percentage over Asha processed by pod pounding at the harvest of farmer's maturity stage ($P \leq 0.01$).

Again Asha processed through pod pounding method and at physiological maturity stage presented a significant difference in germination percentage over Asha processed through pod pounding and at the farmer's maturity stage.

For seed weight, Asha at pod pounding and at physiological maturity showed no significant difference in seed weight over Asha at hand shelling and physiological maturity ($P \geq 0.01$).

Similarly Asontem at pod pounding and physiological maturity presented no significant difference in seed weight over Asontem processed by hand shelling and harvested at physiological maturity stage.

Asontem pods, harvested at farmer's maturity stage and hand shelled showed no significant difference in seed weight over Asontem processed by pod pounding and harvested at farmer's maturity stage.

In the same vain there was no significant difference in seed weight between Asha harvested at the farmer's maturity stage and processed using hand shelling and those harvested at the farmer's maturity stage and processed through pod pounding ($P \geq 0.01$).

However, Asha harvested at physiological maturity stage and processed through pod pounding presented significantly heavier seed weight over Asha processed with pod pounding and at the harvest of farmer's maturity stage ($P \leq 0.01$).

Similarly Asha at hand shelling and at physiological maturity stage is significantly heavier in seed weight than same Asha processed by hand and harvested at the farmer's maturity stage.

For Asontem there was also a significant difference in seed weight when the crop was processed through pod pounding and harvested at physiological maturity stage over same Asontem processed through pod pounding and harvested at the farmer's maturity stage ($P \leq 0.01$)

Similarly Asontem harvested at physiological maturity stage and processed using the hand shelling method showed statistical difference in seed weight over those processed using the hand and harvested at the farmer's maturity stage.

Table 4.3 Interaction effect of variety by seed processing methods and harvesting stages of okra on some seed quality parameters.

Source of variation	Purity (% wt)	Vigour (%)	Germination (%)	Seed weight (g)
Asha * Pod pounding * Physiological	94.33b	44.06abc	79.51b	49.81a
Asha * Hand shelling * Physiological	96.36a	53.13a	83.69a	49.76a
Asontem * Pod pounding * Physiological	94.20b	48.63ab	70.13d	49.26b
Asontem * Hand shelling * Physiological	95.57a	42.68abc	79.94b	49.24b
Asontem * Hand shelling * Farmer's maturity	88.79d	31.38abc	70.19d	45.28c
Asontem * Pod pounding * Farmer's maturity	87.55e	25.57abc	68.13d	45.27c
Asha * Hand shelling * Farmer's maturity	91.41c	20.75c	78.94b	43.35d
Asha * Pod pounding * Farmer's maturity	89.26d	25.13bc	74.35c	43.31d

$P \leq 0.01$

Mean with the same letter are not significantly different

4.4 Effect of maturity stages of okra on some seed quality parameters.

Table 4.4 shows the effect of maturity stages of okra on some seed quality parameters.

Harvesting at the physiological maturity stage differed significantly over harvesting at the farmer's maturity stage in seed purity, vigour, germination percentage and seed weight.

Table 4.4 Effect of maturity stages of okra on some seed quality parameters.

Source of variation	Purity (% wt)	Vigour (%)	Germination (%)	Seed weight (g)
Physiological	95.11a	47.17a	78.32a	79.52a
Farmer's maturity	89.25b	25.70b	73.00b	44.30b

$P \leq 0.01$

Mean with the same letter are not significantly different.

4.5 Effect of variety by processing method interaction on some seed quality parameters of okra

Table 4.5 presents the effect of variety by processing method interaction of okra on some seed quality parameters. Asha variety gave significantly purer seeds in percentage by weight over Asontem with the same hand shelling method of processing. Likewise Asha at pod pounding gave statistical difference over Asontem with the same processing method of pod pounding. Similarly Asha variety at hand shelling differ significantly in purer seeds over same Asha at pod pounding of processing. Asontem also had significantly purer seeds in percentage by weight over same Asontem at pod pounding.

In the seed quality parameters of vigour both Asha and the Asontem okra varieties showed no statistical difference in any of the interactions.

In the area of germination, the result proved significantly different when Asha at hand shelling is compared to Asontem at same hand shelling methods of processing. So also is Asha at pod pounding showed significant difference in seed germination percentage over Asontem at same processing method of pod pounding. Similarly there is significant difference of Asha at hand shelling in germination percentage over same

Asha but at pod pounding method of seed processing. Likewise is Asha at hand shelling significantly different in germination percentage over Asontem at pod pounding method of seed processing.

For seed weight Asontem is significantly heavier in seed weight when the crop is processed using the hand over Asha processed using the same hand shelling method. So also is Asontem processed using pod pounding showed statistical difference in seed weight over Asha processed using same pod pounding method of seed processing.

However there is no significant difference of seed weight of Asha at hand shelling over Asha at pod pounding method of seed processing. In the same vain, there is no statistical difference of seed weight in grammes between Asontem at hand shelling over same Asontem at pod pounding method of seed processing

Table 4.5 Effect of variety by processing method of okra on some seed quality parameters.

Source of variation	Purity (% by weight)	Vigour (%)	Germination (%)	Seed weight (g)
Asha * Hand shelling	93.89a	37.03a	81.31a	46.55b
Asontem * Hand shelling	92.18b	37.03a	35.06b	47.26a
Asha * Pod pounding	91.79b	34.59a	77.13b	46.56b
Asontem * Pod pounding	90.87c	37.09a	69.13c	47.26a

$P \leq 0.01$

Mean with the same letter are not significantly different.

4.6 Effect of processing methods by maturity stage interaction of okra on some seed quality parameters.

Presented on Table 4.6 is the effect of processing methods by maturity stage of okra on some seed quality parameters.

Statistical difference in seed purity is exhibited when seed processing with the hand at the harvest of physiological maturity is compared with pod pounding processing method but at the same harvest of physiological maturity. Similarly hand shelling at the harvest of farmer's maturity stage differ significantly in seed purity over pod pounding processing method at the same harvest of farmer's maturity. In the way hand shelling at physiological maturity has significant purer seeds over processing by the hand method but at the harvest of farmer's maturity stage. So also is pod pounding at physiological maturity stage proved significantly purer in seed over same processing method but at the harvest of farmer's maturity.

In the vigour index of speed of germination, there is no significant difference between hand shelling processing method at physiological maturity over pod pounding at the harvest of physiological maturity stage. So also between hand shelling processing method at the harvest of farmer's maturity and pod pounding method of processing at the same harvest of farmer's maturity showed no statistical difference in seed vigour. However hand shelling at physiological maturity proved significantly different in seed vigour over same hand shelling processing method but at the harvest of farmer's maturity stage. Similar results of significant difference in seed vigour is recorded for pod pounding at physiological maturity over same pod pounding but at the harvest of farmers maturity stage.

In the quality parameters of germination processing by hand shelling and at the harvest of physiological maturity differs significantly in germination percentage over processing using pod pounding method and at same physiological maturity stage. Again, germination percentage presents statistically difference for hand shelling method of seed processing at farmers maturity stage over pod pounding at same farmer's maturity stage. Again, at hand shelling by physiological maturity, germination is significantly different over hand shelling by farmer's maturity stage. In the same vain is pod pounding at physiological maturity significantly differ over same pod pounding but at the harvest of farmers maturity.

In terms of seed weight hand shelling processing method at physiological maturity and pod pounding method at same physiological maturity showed no significant difference in seed weight. So also is hand shelling at farmer's maturity and pod pounding at harvest of farmer's maturity showed no significant difference in weight. However processing using the hand at physiological maturity differ significantly in weight over hand shelling processing at the farmer's maturity. Similarly pod pounding at physiological maturity recorded a significant difference over same pod pounding processing method at the harvest of farmer's maturity.

Table 4.6 Effect of processing methods by maturity stage interaction of okra on some seed quality parameters

Source of variation	Purity (% by weight)	Vigour (%)	Germination (%)	Seed weight
Hand shelling * Physiological	95.96a	47.99a	81.81a	49.50a
Pod pounding * Physiological	94.27b	46.34a	74.82b	49.54a
Hand shelling * Farmer's harvest	90.10c	26.06b	74.56b	44.31b
Pod pounding * farmer's harvest	88.40d	25.34b	71.44c	44.29b

$P \leq 0.01$

Mean with the same letter are not significantly different.

4.7 Effect of processing methods of okra on some seed quality parameters.

The effect of processing methods of okra on some seed quality parameters is shown in Table 4.7. Seed processing method of hand shelling recorded significant difference in the seed quality parameters of percentage purity in weight and in germination percentage over pod pounding processing method. There is however no statistical difference between hand shelling method of processing and pod pounding method in the quality parameters of seed vigour and seed weight.

Table 4.7 Effect of processing methods of okra on some seed quality parameters.

Source of variation	Purity (% by weight)	Vigour (%)	Germination (%)	Seed weight
Hand shelling	93.03a	37.03a	78.19a	46.90a
Pod pounding	91.33b	35.84a	73.13b	46.91a

$P \leq 0.01$

Mean with the same the letter are not significantly different.

4.8 Effect of seed processing methods of two okra varieties on fungal incidence.

Table 4.8 presents the effect of seed processing methods of two okra varieties on fungal incidence. Results from table 4.8 showed that seed processing method of hand shelling and pod pounding have the same level of fungal incidence. The same percentage incidence levels of *Aspergilus flavus*, *Fusarium verticilloides*, *Marcophomina phaseolina* and *Aspergilus niger* were recorded for both processing methods.

Table 4.8 Effect of seed processing methods of two okra varieties on fungal incidence

Source of variation	Fungal Incidence			
	Aspergilus Flavus	*Fusarium Vertcilloides*	*Macrophomina phaseolina*	*Aspergilus niger*
Hand shelling	8.7a	7.88a	7.00a	8.44a
Pod pounding	8.7a	7.88a	7.00a	8.44a

$P \leq 0.01$

Mean with the same letter are not significantly different.

4.9 Effect of Fungal incidence on two okra varieties

Table 4.9 shows the effect of fungal incidence on two okra varieties. Result from the experiment recorded a significant difference in fungal incidence of Asha variety over that of Asontem variety in the fungal species of *Aspergilus flavus*, *Fusarium vertcilloides* and *Macrophomina phaseolina.* There is however no significant difference between Asha variety and that of the Asontem for the fungal specie of *Aspergilus niger*.

Table 4.9 effect of fungal incidence on two okra varieties.

Source of variation	Fungal incidence			
	Aspergilus Flavus	*Fusarium vertcilloides*	*Macrophomina phaseolina*	*Aspergilus niger*
Asha	9.50a	8.50a	7.25a	8.86a
Asontem	8.00b	7.25b	6.75b	8.00a

$P \leq 0.01$

Mean with the same letter are not significantly different.

4.10 Effect of maturity stages of two okra varieties on fungal incidence.

Presented on Table 4.10 is the effect of maturity stages of two okra varieties on fungal incidence. Results indicated farmer's maturity differing significantly over harvesting at physiological maturity in all the fungal incidences of *Aspergilus flavus, Fusarium vertcilloides, Macrophomina phaseolina and Aspergilus niger.*

Table 4.10 Effect of maturity stages of two okra varieties *on fungal incidence.*

Source of variation	Fungal incidence			
	Aspergilus Flavus	*Fusarium verticilloides*	*Macrophomina phaseolina*	*Aspergilus Niger*
Farmer's maturity	13.50a	12.13a	10.88a	13.00a
Physiological	4.00b	3.60b	3.13b	3.88b

$P \leq 0.01$

Mean with the same letter are not significantly different.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Assessment of varietal differences of okra on some seed quality parameters.

Between the two prominent varieties grown in the study area the Asha variety showed a higher seed purity over that of the Asontem variety (Table 4.1). This could be as a result of varietal differences in their varietal characteristics. Again the lower seed purity recorded by the Asontem could also mean that this variety is easily susceptible to mechanical damage or cracks to the seed coat which compromise with seed purity as documented by (Bishaw and Van Gastel, 1993).

The lower seed germination percentage recorded by the Asontem over the Asha variety could also be as a result of varietal characteristics which could mean mechanical or internal physiological barriers which could prevent optimum seed germination as documented by Opeke (1982) (Table 4.1). Again the lower seed germination percentage of Asontem could be due to its higher seed dormancy rate over that of the Asha variety, confirming earlier findings by Madsen (1988) that seed dormancy is that which seeds will not germinate despite favourable external conditions which may be due to endogenous factors. On the other hand the heavier seed weight of Asontem over Asha could mean an influence in its germination percentage, seed vigour and seedling establishment and yield as established by (Noor Mohammadi et al; 2000: Cordazzo, 2002).

5.2 Assessment of variety and maturity stages interaction on some seed quality parameters.

Higher seed percentage purity by weight was recorded by Asha at physiological maturity over those harvested at the farmer's maturity. So also is Asha purer in seed over Asontem when both are harvested at the farmer's maturity (Table 4.2).

The lower seed purity at the farmer's maturity stage could be as a result of long delay in harvesting the crop from the field which could affect its purity and for that matter seed quality. There is therefore positive correlation between the time of crop harvest and seed purity. This is very critical to production, productivity and market value as contended by Mather and Kongsdal (2003). Harvesting at the farmer's maturity stage not only would it increase production cost but also substantially would reduce the quality of the harvest as noted by Colorado state university (2015).

There is no statistical difference in seed purity between the two varieties of Asha and Asontem at the physiological maturity stage but the variety recorded significant difference in seed purity over that of Asontem variety at the farmer's maturity. The higher seed purity of the Asha over the Asontem could be due to varietal characteristics which could see the Asontem variety more susceptible to seed deterioration after physiological maturity.

Findings from the study recorded higher seed vigour in terms of speed of germination for the Asha variety at physiological maturity over same Asha harvested at the farmer's maturity (Table 4.2). When both varieties are harvested at physiological maturity, no statistical difference in seed vigour was recorded. Higher vigour of seed at physiological maturity is an indication that seeds harvested at physiological

maturity could have longer shelf life and thus could store better than seeds with lower vigour (www.niab.com).

For the parameters of germination, harvesting at the physiological maturity proved significantly different for both varieties (Table 4.2).

Asha differ significantly in seed germination percentage at physiological maturity over same variety harvested at the farmer's maturity. So also is Asontem at physiological maturity differ significantly in seed germination over those harvested at farmer's maturity, confirming the assertion by Gardner et al. (1985) that at physiological maturity, germination is highest and decline thereafter. Harvesting of seeds at physiological maturity irrespective of the variety therefore would enhanced seed germination and by inference high seed quality.

The seed weight of Asha differ significantly over Asontem when both varieties were harvested at the physiological maturity stage. So also is the Asha significantly heavier than Asontem harvested at farmer's maturity stage (Table 4.2). From the experiment if was realized that irrespective of the variety and the time of maturity stage, seed weight differ significantly by the Asha variety over that of the Asontem variety and also seed weight is heavier at the harvest of physiological maturity over those at the farmer's maturity. By inference Asha is expected to perform better than Asontem since as documented by Moshatati and Ghariueh (2012) thousand seed weight is one of the important scales of seed quality that influences on germination, seed vigour, seedling establishment and yield.

5.3 Assessment of the interaction effect of variety by seed processing methods and harvesting stages of okra on some seed quality parameters.

Seed analytical quality (Purity) was done to determine the percentage composition by weight of the sample being tested and so identify the various seed and inert materials constituting the sample.

Purer seeds were realized from Asha harvested at physiological maturity with hand shelling processing method over those processed using the pod pounding method with the same physiological maturity (Table 4.3). Similar result was recorded for Asontem variety at physiological maturity with hand shelling over same Asontem at the physiological maturity but with pod pounding method of processing. Again Asontem with hand shelling at farmer's maturity produced purer seeds over those with pod pounding with same farmer's maturity. So also is Asha at hand shelling with farmer's maturity recorded purer seeds in percentage by weight over same Asha at pod pounding with farmer's maturity.

Even though from purity analysis, no other crop seed were recorded in any of the interactions, it is however realized that more foreign materials were found in the interactions at the farmer's maturity at both the pod pounding and hand shelling processing methods over those varieties at the interaction of physiological maturity with pod pounding and hand shelling processing methods. The foreign or inert materials turn to compromise the purity of such seed. At the farmer's maturity, the seeds could already be infested with pest and fungal spores thereby leading to seed deterioration before they are harvested. When this pods undergo further seed processing especially using pod pounding method further seed quality is affected as a possible result of mechanical damage to the seeds as documented by (Bishaw and Van Gastel, 1993). All these factors could contribute to the less purer seeds noticed in the

farmer's maturity interactions. As reported by Mathur and Kongsdal (2003) sowing of pure seeds is critical for improving crop yield and increased food production.

On the issue of seed vigour, test was for the purpose of discriminating between seed lots for suitability for storage and for purposes of discriminating between seed lot for planting value in relation to optimizing establishment or promoting synchronous seed emergence.

Seed vigour was determined by speed of germination (Table 4.3). Results from this experiment revealed that similar maturity stages of harvest but with different processing methods have no significant effect on seed vigour index of speed of germination. The experiment also revealed that harvesting of Asha with hand shelling and at physiological maturity gave significant purer seeds over processing of same Asha variety with hand shelling processing method at farmer's maturity stage. This once again goes to confirm the report by (Gardner et al; 1985) that harvesting at physiological maturity stage of seeds gave higher vigour and germination percentage. The findings also showed that Asha variety at physiological maturity could store better with hand shelling than that of Asha with hand shelling but at the farmer's maturity as documented by (Caddick 2007).

For Asontem variety, there was no statistical difference in vigour index of speed of germination in percentage in any of the comparative interactions. This could be due to similar vigour varietal characteristics.

Germination test on the interactions were carried out to determine the maximum germination potentials of the varieties and the field planting value of the seeds in the soil.

The experiment recorded a higher germination percentage of Asha at physiological maturity with hand shelling over those of pod pounding processing for both pod pounding and hand shelling at the farmer's maturity stage of harvest (Table 4.3). This once again confirming earlier findings by (Gardner et al., 1985) at physiological maturity of seeds have higher germination potentials and this decline down the maturity line. By this higher germination at physiological maturity stage of harvest, Asha is expected to perform or have high field planting value and by inference high production and productivity. The lower germination potential of Asha with pod pounding and hand shelling processing methods at the farmer's maturity of harvest could be as a result of stage of maturity at harvest, mechanical damage during processing and pathogen attack as documented by (Tomer and Maguire 1990).

Similar result was recorded for the Asontem with hand shelling processing method at physiological maturity over same Asontem with hand shelling but with the farmer's stage of maturity confirming similar finding by (Gardner et al., 1985) that at physiological maturity, seeds have higher germination potentials and this decline down the maturity line. The result of Asontem with hand shelling processing method at the harvest of farmer's maturity, showing no difference over same Asontem with pod pounding with same harvesting at the farmer's maturity indicates that processing methods of hand shelling and pod pounding have the same effect on germination.

On seed weight, the study showed that similar maturity stages of harvest for both processing method of pod pounding and hand shelling for both varieties have no differential effect on seed weight. The effect of the interactions on seed weight also revealed that heavier seed weight is only registered for the different maturity stages of harvest with similar processing methods for the two varieties. The implication is increased germination percentage, seedling emergence, tillering and yield (Noor-

Mohammadi et al. (2000); Cordazzo, (2002). The lighter seed registered at the farmer's maturity over those harvested at the physiological maturity could be attributed seed seed quality deterioration on field before harvesting and processing. Pest infestation on the field before harvesting could lead to the infestation of the seed's endosperm thereby reducing seed weight.

5.4 Assessment of maturity stages on some seed quality parameters of okra

Findings from the experiment recorded higher seed purity in percentage by weight, vigour in percentage, seed germination in percentage and heavier seed weight in grammes at physiological maturity of harvest over harvesting at farmer's maturity stage (Table 4.4). The above finding is very critical to seed quality. Harvesting at physiological maturity of seed is therefore essential to maintaining the quality if seeds which are vital for production and productivity.

Seeds harvested from physiological matured crops are thus expected to perform better than seed got from that of the farmer's maturity stage. This goes to support the contribution of Mathur and Kongsdal (2003) that sowing of high quality seed is essential for improving crop yields and increased food production.

5.5Assessment of variety and processing methods interaction on some seed quality parameters of okra

Results of the interaction of seed purity indicated a purer seeds of Asha over Asontem in both processing methods of hand shelling and pod pounding. Similarly purer seeds are produced by Asha of hand shelling over those at pod pounding method of

processing. So also is Asontem producing purer seeds at hand shelling over pod pounding processing method of seed (Table 4.5). The differences in the purity levels of Asha at hand shelling over Asontem at same hand shelling and Asha at pod pounding over Asontem at same pod pounding could be due to levels in their varietal characteristics where the Asontem could be more susceptible to pests and fungal spores and even to mechanical damage all of which contribute to seed impurities or inert materials according to ISTA (2003) seed purity determination procedures.

Findings from the research on seed vigour revealed that for both the Asha and Asontem varieties the processing methods had similar effects on seed vigour (Table 4.5).

However, the differences in purity between Asha at hand shelling over Asha at pod pounding and Asontem at hand shelling over same Asontem at pod pounding could be due to the fact that by pod pounding processing methods, heavy mechanical damages could have been caused to the seeds thereby compromising with the seed purity according to ISTA (2007) seed purity rules.

The interaction effect of the Asha and Asontem and seed processing methods on germination recorded higher germination percentage of Asha over Asontem at both hand shelling and pod pounding processing methods (Table 4.5). This findings have shown higher seed quality of Asha over Asontem variety which could once again be attributed to varietal differences. Asha variety is therefore more superior to the Asontem variety in the quality parameters of seed germination which according to Barua et al. (2009) is the most important function of a seed as it is an indicator of its viability and growth. The experiment has also shown that processing method using hand shelling resulted in higher seed germination percentage than processing by

pounding. This could be due to mechanical damage or injuries caused to the seeds when processing by the pod pounding. Kelly (1988) reported that mechanical damage caused to seeds in the form of cracks or broken seeds are unlikely not to germinate satisfactorily.

On the interaction effect of variety and processing methods on the seed weight heavier seed weight were recorded for Asontem variety using both processing methods processing methods. There is however similar seed weight recorded for Asha at hand shelling over same Asha at pod pounding and same seed weight recorded for Asontem at hand shelling over same Asontem at pod pounding processing method (Table 4.5). The resulting effect of this findings is that the heavier weight of Asontem over Asha could influence on seed germination of Asontem as documented by (Gorge and Ray 2004) that increase in seed weight leads to the increase in germination of seeds. The result of Asha at hand shelling over Asha at pod pounding and Asontem at hand shelling over same Asontem at pod pounding gives the implication that the processing methods of hand shelling and pod pounding have similar effect on seed weight and that seed weight cannot be influenced by such interactions.

5.6 Assessment of processing methods by maturity stage interaction of okra on some seed quality parameters.

The experiment has revealed a higher seed purity in percentages by weight from hand shelling at physiological maturity over pod pounding processing method at the harvest of physiological maturity. Similarly higher seed purity was recorded for processing from hand shelling at the farmer's maturity stage of harvest over the processing method of pod pounding at the harvest of same farmer's maturity. So also is pure seeds realized from hand shelling at physiological maturity over same hand shelling at the farmer's maturity of harvest. Again purer seeds are obtained from pod pound processing method at physiological maturity of harvest as compared to pod pounding at farmer's maturity.

The differences in the purity levels between hand shelling and pod pounding at physiological maturity could be the result of damages caused to the seeds through the processing method which could led to the introduction of impurities or inert materials as noted by ISTA (2007).

Again, the lower seed purity recorded for pod pounding processing method over hand shelling at farmer's maturity could be the result of seed damage through pod pounding coupled the long delay on the field of the farmer's maturity which turns to compromise with seed purity.

The lower seed purity level for pod pounding at farmer's maturity over hand shelling at physiological maturity could also mean introduction into the seed lot as a result of moulds, fungal spores and pest as a result of long delay in the harvesting at the farmer's maturity and mechanical damage to the seeds. All these compromise seed purity according to ISTA (2007) .

Since there are no differences in seed vigour for these classes of seed lot, the rate and uniformity of seed germination and emergence as well as seedling growth shall be the same as documented by Delouche (1974). However, higher seed vigour index of seed germination were observed for seeds of hand shelling at physiological maturity over hand shelled seed of farmer's maturity. This could be as a result of the different stages of maturity. At the farmer's maturity, seeds stayed on the field longer and are most often associated with pest infestation, fungal spores and moulds all of which reduces seed quality and as such vigour (ISTA,1979).

Again higher seed vigour is recorded for seeds of pod pounding at physiological maturity over seeds of same pod pounding but the farmer's maturity. The lower vigour could be as a result of the processing by pod pounding which could lead to mechanical damage to the seed coat or the embryo or stage of maturity at harvest and microbial activities as established by (Bishaw and Van Gastel (1993) and (Tomer and Maguire, 1990). Plants from such seeds could be expected to show stunted growth and abnormalities in the developing shoots and root system and subsequently affect crop establishment as noted by Caddick (2007).

On germination percentage, hand shelling at physiological maturity had higher germination percentage over processing by pod pounding but at the same physiological maturity. This again confirms earlier ascertion by Kelly (1988), that cracks or broken seeds in a seed lot are likely not to germinate satisfactorily.

Again processing using hand shelling had higher seed germination percentage over processing with the hand at the farmer's maturity of harvest.

Harvesting at physiological maturity as indicated in Tables 4.3, and 4.4 led to higher germination percentage over harvesting at the farmer's maturity (Gardner *et al*., 1985). Similarly, with pod pounding at physiological maturity higher seed germination is achieved over pod pounding at the farmer's maturity. Though the germination with pod pounding at physiological maturity was significant, it was lower than that of hand shelling at the physiological maturity stage of harvest, a situation which could be attributed to mechanical damage as a result of pounding thereby negatively affecting seed germination, Kelly (1988), that cracks or mechanical damage to seed lot are likely not to germinate satisfactorily.

Findings on seed weight recorded no effect of processing method of hand shelling and pod pounding at physiological maturity. So also there was no difference in weight of hand shelling and pod pounding at farmer's maturity (Table 4.6). Seed weight cannot therefore be improved at this interaction levels of processing methods as against maturity stages. However processing by hand shelling at physiological maturity have higher seed weight over processing using same hand shelling but at farmer's maturity. Similar heavier weight was recorded for pod pounding at physiological maturity over same pod pounding but at the farmer's maturity.

The lower seed weight recorded for the farmer's maturity once again pointed to the fact that at the farmer's maturity the delay on the field affects seed quality parameter of weight through pest infestation, fungal spores and mould as documented by Wicklow (1981) that fungi are the primary cause of seed deterioration which is depicted by the loss of dry matter.

Heavier seed weight with hand shelling at physiological maturity could mean good seed quality which could have better seed performance over those of farmer's maturity as recorded by (Noor-Mohammadi et al, 2000; Cordazzo, 2002).

5.7 Assessment of processing methods of okra varieties on some seed quality parameters

Findings from the experiment showed that processing by hand shelling had more effect on the quality parameters of seed purity in percentage by weight and in germination percentage over that of the pod pounding. There was however no significant difference on the seed quality parameters of vigour and seed weight (Table 4.7).

The lower seed germination percentage registered by the pod pounding processing method could be as a result of mechanical damage caused to the seed coat during the processing process confirming earlier findings by Moshatati and Ghariueh (2012). The comparatively lower seed purity for pod pounding could be attributed to the nature of the processing method which has a greater potential of adding to the seed lot cracked seeds and other foreign materials according to ISTA (2007) seed rules. This materials in the seed lot turn to compromise with the seed's quality which is critical to production and market value as reported by (Mathur and Kongsdal 2003). Seeds for planting should be pure. According to (Kelly, 1988) good physical qualities of seed are generally expected to perform better than less purer seeds.

The result also showed that seed processing can be done using hand shelling and pod pounding methods with the same compromising effect on the seed quality parameters of vigour and weight.

5.8 Assessment of seed processing methods, variety and maturity stages on fungal incidence of two okra varieties.

Seed processing methods of hand shelling and pod pounding as indicated by the result had the same levels on fungal incidence of *Aspergillus flavus, Fusarium vartcilloides, Macrophomina phaseolina* and *Aspergillus niger* (Table 4.8). Fungal incidence levels is therefore not altered by seed processing methods.

Four species of fungal incidence were also noticed on the two okra varieties with different levels. Asha showed greater levels of incidence over Asontem in the fungal species of *Aspergillus flavus, Fusarium vertcilloides, Macrophomina phaseolina* except for the species of *Aspergillus niger* which recorded no significant difference in the fungal incidence levels (Table 4.9). This trend could be attributed to differences in their varietal characteristics where the Asha variety could be more susceptible to the fungal species than the Asontem variety and should inform seed users of the choice of okra varieties when fungal incidence is concern.

The higher levels of fungal incidence recorded by the farmer's maturity could be traced to the long delay of the crop on the field before harvesting.

This higher levels of fungal incidence recorded by the farmer's maturity could also have had an effect on lower seed germination recorded as fungal pathogens are contributing factors to poor seed germination (Anjorin and Mohammed, 2009).

Even though ISTA (1979) documented that okra, tomato, hot pepper, maize, wheat and cowpea seeds severely infected with disease and pest failed to germinate the levels of germination percentage recorded by the farmer's maturity at harvest could mean that the presence of fungi species on the seeds did not necessarily result in disease conditions as noted by (Jindal and Thind, 1990).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

1 The study has revealed that except for fungi incidence among the seed quality parameters of purity, vigour, germination and a thousand seed weight, the Asha variety has presented a better option to that of the Asontem variety.

2 The study has also revealed that, the stage of maturity for harvesting plays a key role on purity, seed vigour, germination, seed weight and on the incidence levels of fungi. Harvesting at the physiological maturity stage therefore gave a better result over harvesting at the farmer's maturity stage in all the seed quality parameters.

3 Even though processing by hand shelling did not produce any better alternative to pod pounding in the quality parameters of vigour, levels of fungi incidence and seed weight, it was batter over pod pounding in seed purity and seed germination which matters most in seed quality parameters.

In the combination effect of variety, processing methods and maturity stages of harvest, harvesting at the physiological maturity stage, with hand shelling processing method gave an overall better option to harvesting at the farmer's maturity stage with pod pounding.

6.2 Recommendation

1 To increase seed quality, farmers should endeavor to adopt measures that would enhance seed quality especially the maturity stage of harvest and methods used to process the seed.

2 The engineering departments of the faculties of agriculture of the country's universities should try to design simple okra cracking machines to facilitate efficiency and effectiveness in the farmer seed processing activities for increased seed quality.

3 Since the study did not look at storage component, it is proper to conduct further studies on the effect of storage on the study.

REFERENCES

African journal of Agricultural Research. (2010). Vol 5 pp 3590-3598

Agrawal, P.K (1995). Seed storage and packaging. In Techniques in seed science and technology 2nd Edition. P.K. Agrawal and M. Dadlani (Eds). South Asians Publishers, New Delhi. Pp 159-163.

Al- Yahya, S.A. (2001). Effects of Storage Conditions on Germination in Wheat. analysis. Ind Cro and Pro 23:59-63. and the growth of root seedlings. Sci Hor 98:247-256. DOI.

Anjorin, S. T. and Mohammed, M. (2009). Effects of Seed-borne Fungi on Germination and Seedling Growth of Watermelon (*Citrullus lanatus)* J. Agric. Soc. Sci., Vol. 5, No. 77-80.

Anonymous (2009). "*GHANA: Plummeting Profits Drive Tomato Farmers to Suicide*" IRIN. April, 2009. Humanitarian News and Analysis.

AOSA (1981) Rules for Testing Seeds, Journal of seed Technology Volume 6, Number 2 Pp 31

Barua, H, Rahman, M.M and Masad, M.M. (2009). Effects of storage containers environment at different storage period on the quality of chlli seed. International journal of sustainable crop production. 4 (4): 28-32

Basu, R. N. (1990). Invigoration for extended Storability and Processing: International Conference on Seed Science and Technology. New Delhi.

Basu, R. N. (1995) Seed Viability. In. Seed Quality: Basic Mechanisms and Agricultural Implications. Amarjit, S. Basra (Eds). Food Product Press. An Imprint of the Haworth Press Inc. New York, London, Norwood (Australia). Pp 1-5.

Basu, R.N. (1990).Invigoration for external Storability and Processing: International conference on Seed Science and Techno logy. New Delhi.

Bishaw, Z. and Van Gastel, A. V. G. (1993). Seed vigour and its measurement. In *Techniques in seed science and Technology*. South Asian Publishment Pvt Ltd. 56 Sidharth Enclave, New Delhi, India. Pp 289.

Byrum, J.R. and L.O. Copeland (1995). Variability in vigour testing of maize (*Zea mays L*.) seed. *Seed Sci. & Technol*. 25:53-549.

Caddick, L. (2007). Loss of seed germination: what are the reasons? CSIRO stored Grain Reasearch Laboratory, 98-2007, CSIRO, Australia.

Cantliffe, J.D. (1998). Seed Germination for Transplants. Hort. Technology 8 (4). Florida Agricultural Experiment Station Journal Series N-01421.

Chopra, K. R. (1982), Technical Guidelines for sorghum and millet seed production. FAO, Rome

Colorado state University /Extension specialist, soil and crops sciences and directors of Colorado seeds programme. 3/95. Revised 12/14 updated Tuesday February 05 2015

Copeland L. O. and McDonald, B. M. (1995). Seed Science and Technology. 3rd Edition. Chapman and Hall 115 Fifth Avenue New York NY 10003. USA. Pp 112-169.

Copeland, L. and McDonald, M. (1995). Principles of Seed Science and Technology. 3rd ed. Chapaman and Hall.

Cordazzo C.V. (2002). Effect of seed mass on germination and growth of three dominant species in Southern Brazilian coastal dunes. Bra J Bio 62:427-435

Cromwell, E., Wiggins, S. and Wentzel, S. (1993). Sowing Beyond the State: NGOs and Seed Supply in Developing Countries. Overseas Development Institute, London, UK.

Delouche, J.C. (1974). Maintaining soybean seed quality. In: *Soybean: Production, Marketing and Use*. NFDC, TVA, Muscle Shoals, Alabama. Bull. Y-69:46-62.

Diaz, C., Hossain, M, Bose, M.L; Mercea, S. and Mew, T.W. (1998). Seed quality and effects on rice yield: findings from farmers participatory experience in central Luzon Philippines. Journal for Crop science 23(2), 111-119.

Diekman, M. (1996). Seed-borne diseases in seed production. In Seed Science and Technology. Proceedings of a train-the trainers Workshop 24 April to 9 May, 1993, Aman Jordan. (eds) A. J. G. Van Gastel, Pagnotta, M. A and E. Porceddu. International Center for Agricultural Research in the Dry Areas (ICARDA), Allepo Syria. Pp 259-268

Driscoll, C. J. (1990). Plant Sciences Production, Genetics and Breeding. Ellis Horwood Market Cross House, Cooper Street, Chichester West ussex, P019 IEB, England. Pp 35

Duzyaman E. (1997). Okra: botany and horticulture. HORT. Rev. 21:48-68

Duzyaman, E. (1997). Okra: Botany and Horticulture. Horticulture review 21; 41-72

Dzomeku, M.B Osei, C.K. (2005) Factsheet. Tissue Manipulation Technique: New horticultural Technique for mass production of plantain suckers CSIR-Crop Research Institute, Kumasi. Ghana. Training communication and publication unit.

Ellis, R.H. (1991). Seed and seedling vigor in relation of crop growth and yield. *Plant Growth Regulation*, v. 11, n. 1, p. 249-255.

Fact sheet (2009): Good quality seed. International rice institute

FAO (1981). Cereal and grain-legume seed processing. Technical Guidelines. No. 21 Walther P. Freistritzer, Helmer Vock, A. Fenwick Kelly and Ernest Kreu Ziger (Eds). FAO. Rome. Pp 3, 33-43, 51-53.

Gardner, P. F., Pearce B. R., Mitchell, L. R. (1985). Physiology of Crop Plants Iowa State University Press. AMES. Pp 221-225.

Gorge MHA, Ray DT. (2004). Germination characterization of Guayule (Parthenium argentatum) seed by morphology mass and X-ray and analysis.Ind Cro and Pro 23;59-63

Guberae, V., Marie, S., Lalic, A., Drezner, G., Zdunie, Z. (2003). Hermetically Sealed Storage of Cereal Seeds and its Influence on Vigour and Germination. *Journal of Agronomy and Crop science* 189, 54-56.

Hadidi A.N. (1996). Ecology Seed Germination physiology. In. Seed Science and Technology, proceedings of a Train-the-Trainer Workshop Sponsored by Med-Campus Programme (EEC) 24 April to 9 May 1993, Amman, Jordan. ICARDA, Aleppo, Syria. V11 +311 Pp77.

Hampton, G. J and Coolbear, P. (1990). Seed Science and Technology. Proceedings of the International Seed Testing Association. Vol. 18(2). Pp 215-228.

Hampton, J.G. (2002). What is seed quality? *Seed science and Technology* 30:1-10.

Heatherly, L.G. and Elmore, R.W., (2004). Managing Inputs for Peak Production. In; *soybeans: Improvement, Production and Uses.*eds by Boerma H.R., Specht, J.E., 3rd Edition. *Agronomy* N-16, ASA, CSSA, SSSA, Madison, Wisconsin, USA, 451-536.

Hewett, P. D. (1981) Seed standards for disease in certification, Journal of the national Institute of Agricultural Botany, 15, 373-84.

Horna, D., Melinda Smale, and Jose Falck-Zepeda (2006). Assessing the Potential Economic Impact of Genetically Modifield Crops in Ghana: Tomato, Garden Egg, Cabbage and in processing tomatoes. *Scientia Horticulturae*, 27, 189-198.

House, L.R. (1985), A guide to sorghum Breeding. 2nd edn. International Crops Research Institute for the Semi-arid Tropics. Patancheru AP 502 324 India.

Hughes J. (2009). Just famine foods? What contribution can underutilized plants make to food security? Acta Horticulture 806:39-47.

ISTA (1979). ISTA hand book for seed Evaluation. J. Bekendam, R. Grob (Eds) ISTA Germination Committee. Zurich, Switzerland. Pp 4-7

ISTA (1986). ISTA Handbook on seed sampling. (Eds) A Bould International seed Testing Association (ISTA) Zurich, Switzerland. Pp 1.

ISTA (1993). International Rules for Seed Testing, Rules 1993. International Seed testing Association. Zurich, Switzerland. Pp 25.

ISTA (2007). International Rules for seed Testing, Rules 1993. International seed Testing Association, 2007 Edition, Chapter 5 pp 1, Chapter 7 pp 1.

Jindal, K. K. and Thind, S. B. (1990). Microflora of cowpea seeds and its significance in the biological control of seed-borne infection of Xanthomonas campestris pv. Vignicola. Seed Science and Technology. Proceeding of the international seed Testing Association.Vol.18 (2).Pp 393-403.

Kelly, A. Fenwick (1988). Seed production of agricultural crops. Longman Group UK Limited, Longman House, Burnt Mill, Harlow, Essex CM20 2JE, England pp 29-30.

Kelly, A. Fenwick (1988).Seed production of agricultural crops. Longman House, Burnt Mill. Harlow.Harlow.Essex CM20 2JE.England.pp39

Khan, M.L. (2003). Effects of seed mass on seedling success in Artocarpus heterophyllus L. a tropical tree species of north- east India. Act Oec 25;103-110

Kochhhar, S.L. (1981). Tropical crops. A text book of Economy Botany. pp 263-26

Lanteri, S. and Quagliotti, L. (1997). Problems related to seed production in the African region. *Euphytica* 96: 173-183.

Madsen Erik (1988). Introduction To germination of Seeds. A review for Teaching Purposes In Seed Testing At The Danish State Seed Testing Station 2nd Edition.DK-2800,LYNGBY,Danmark.Pp13-14.

Malcolm, P.J., Holford, P., Mc-Glasson, W.B. and Newman, S. (2003). Temperature and seed weight affect the germination of Peach rootstock seeds and the growth of root stock seedling.Sci Hor 98;247-256.DOI.

Maloy, O. C. (1993). Plant Disease Control. Principle and practice. John Wiley and sons Incorporated. Pp225.

Mathews, S. and Powell, A, A. (1995). Seed vigour and its measurement. In. Techniques in Seed Science and technology. 2nd Edition. (Eds) Agrwal, P. K. and dadlani, M. South Asian Publishers New Delhi, Indian. Pp101.

Mathur, S. B. and Kongsdal, O. (2003). Common Laboratory Seed Health Testing Methods for detecting Fungi.ISTA.Pp1-4

Mathur, S.B.; Njala M. and Kongsdal, O. (2003) An Illustration Handbook on Normal and Abnormal Seedlings of Tropical and sub-Tropical Crops. Danish Government Institute of Seed Pathology for Developing Countries. Thorvaldsenwej 57; 1871 Fredriksberg C. Copenhagen, Denmark. Pp1-5.

Marthur, S. B. and Olga Kongsdal (2003). Common laboratory seed health testing methods for detecting fungi published by the International Seed Testing Association (ISTA). Bassersdorf, CH., Switzerland. Pp.89.

Maude, R.B. (1988). Seed-borne Diseases and Their Control. Principle and Practice. CAB International. Pp 189-191, 267.

Mew, T.W. and Gonzales, P. (2002). A handbook of Rice seed-borne Fungi: ⎪RR⎪.

Mew, T.W. Misra, J.K. and Merca, S.D. (1994). A Manual of Rice seed Health Testing, International Rice Research Institute, IRRI, Pp: 3

Ministry of Food and Agriculture. (2011).Offinso-North District Crop survey and farmers Registration sheet from 16 operational areas.

Morre, G. and Tymowski, W. (2005). Explanatory Guide to the International Treaty on plant Genetic Resources and Food Agriculture, IUCN.

Moshatati , A. and Ghariuch, M.H . (2012) Effect of grain weight on germination and seed vigour of wheat.Dept of Agronomy and Plant Breeding; Ramin University of Agriculture and Natural resouces,Mollasani Ahwaz,Iran.Intl J Agri Crop Sci Vol 4 (8) 458-460.

NAP (National Academic Press) (2006). Lost crops of Africa volume 11: vegetables. www.nap.edu/catalog/11763.html;pp 287-301.

Neergaard, p. (1979).Seed Pathology vol.1 The Macmillan Press Ltd London and Basingstoke, UK.Pp 285-288.

Noor-Mohammadi Gh, Siadat A, Kashani A. (2000). Agronomy (cereal), Ahwaz University press. Pp446

Opeke K. L. (1982). Tropical Tree Crops. Nigeria. Spectrum Book Ltd, Sunshine House, Second Commercial Road, Oluyole Estate Ibadan. 26-29.

Powell and Mathews (1995). Seed vigour and its measurement. In. Technoques in Seed science and technology 2nd Edition. P. K. Agrawal and M. Dadlani (Eds).South Asians Publishers, Pvt Ltd. 56 Sindhartha New Delhi. Pp 159-163.

Rao, P. U. (1985) .Chemical composition and biological evaluation of okra seed and their Kernels.Plant Food for Human nutrition 35 339-396.

Rindels, S. (1995). Seed Viability, Horticulture and Home Pest News, Dept. of Horticulture, lowa State University. Pp 16.

Rules for testing seed (1981). Association of official seed Analysis Journal of seed Technology Vol 6 Number 2 P31

Rules for testing seed (1981). Association of official seed Analysis Journal of seed Technology. Vol 6 Number 2 P31

Schmidt, L. (2000). Guide to handling of Tropical and Sub-tropical Forest Seed. Danida Forest Seed Centre. Pp4-40.

Shetty, H.S. (2000). Seed health testing and its role in plant protection. Proceedings. 1999-National seminar on Seed Science and Technology, (Shetty, H.S. and H.S. Prakash, Eds.). 1st Edn. Dept. of Applied Botany and Seed Pathology, University of Mysore, India, pp; 76-78

Siemonsma J S (1982). West Africa Okra – morphorlogy and cytogenetical, indicator, for the existence of a natural amphidiploids of Abelmoschus (L) and A. manihot (L.) mediks. Euphytica 31; 241-250.

Simic B., Popovic, S., Tueak, M., (2004). Influence of Corn (*Zea mays L.*) inbred lines seed processing on their damage. *Plant, Soil and Environment* 50, 157-161.

Simic, B., Popovic, R., Sudaric, A., Rozman, V., Kalinovic, I. and Cosic J. (2007). Influence of storage condition on seed oil content of maize, soybean and sunflower. CCS Agriculture Conspectus Scienticus. Vol. 72, No. 3 Pp 211-213.

Sinnadurai, S. (1973). Vegetable Production in Ghana. *Acta Hort.* (ISHS) 33:25-28. Smith, O.E.; Welch, N.C.; Mccoy, O.D. (1973). Studies on lettuce seed quality. 11. Relationship of seed vigor to emergence, seedling weight and yield. *Journal of American Society of Horticulture Science,* v. 98, n. 3, p. 552-556.

S. Kumar, S. Dagnoko, A Haougui A ratnadass, D. Pasternak , C. Kouame. (2010) African journal of Agricultural Research. Vo1 5 pp 3590-3598.

Tanaka, Y. (1984). Assuring Seed Quality for Seedling production: Cone Collection and Seed processing, Testing, Storage, and Stratification. In. Forest Nursery Manual: Production of Bareroot seedlings. Martinus Nijhoff/Dr.Junk Publishers, the Hague. Pp27-33

Tomer, S. P. R. and Maguire, D. J. (1990).Seed Vigour Studies in Wheat. Seed Science and Technology. Proceedings of the International Seed Testing Association. Vol.18 (2) Pp383-392.

Wicklow, T. Donald (1995). The Mycology of Stored Grain: An ecological Perspective. In. Stored-Grain Ecosystems. (Eds) Dirgrir, S. Jayas, Noel D. G. White and William E. Muir. Marcel Decker Incorporated, New York. Pp197-205.

Wu Wen-Shi and Cheng Kuang-Che (1990). Relationship between seed health, seed vigour and performance of sorghum in the field. Seed Science and Technology. Proceedings of the International Seed Testing Association. Vol. 18 (2) Pp713-719.

www.niab.com/pages/id/24/seed quality.

APPENDICES

APPENDIX 1: ANOVA PAIR COMPARISON

Student Edition of Statistix 9.0 08/05/2015, 15:20:00

LSD All-Pairwise Comparisons Test of GERMINATION for VARIETIES

VARIETIES	Mean	Homogeneous Groups
ASHA	79.222	A
ASONTEM	72.094	B

Alpha 0.01 Standard Error for Comparison 0.5206
Critical T Value 2.831 Critical Value for Comparison 1.4740
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
All 2 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of GERMINATION for HARVESTING

HARVESTIN	Mean	Homogeneous Groups
PHYSIO	78.316	A
FARMER H	73.000	B

Alpha 0.01 Standard Error for Comparison 0.5206
Critical T Value 2.831 Critical Value for Comparison 1.4740
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
All 2 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of GERMINATION for VARIETIES*PROCESSIN

VARIETIES	PROCESSING	Mean	Homogeneous Groups
ASHA	HAND S	81.313	A
ASHA	POD P	77.131	B
ASONTEM	HAND S	75.063	B
ASONTEM	POD P	69.125	C

Alpha 0.01 Standard Error for Comparison 0.7362
Critical T Value 2.831 Critical Value for Comparison 2.0846
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are 3 groups (A, B, etc.) in which the means
are not significantly different from one another.

LSD All-Pairwise Comparisons Test of GERMINATION for VARIETIES*HARVESTIN

VARIETIES	HARVESTIN	Mean	Homogeneous Groups
ASHA	PHYSIO	81.600	A
ASHA	FARMER H	76.844	B
ASONTEM	PHYSIO	75.031	B
ASONTEM	FARMER H	69.156	C

Alpha 0.01 Standard Error for Comparison 0.7362
Critical T Value 2.831 Critical Value for Comparison 2.0846
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are 3 groups (A, B, etc.) in which the means are not significantly different from one another.

LSD All-Pairwise Comparisons Test of GERMINATI for PROCESSIN*HARVESTIN

PROCESSIN	HARVESTIN	Mean	Homogeneous Groups
HAND S	PHYSIO	81.813	A
POD P	PHYSIO	74.819	B
HAND S	FARMER H	74.563	B
POD P	FARMER H	71.438	C

Alpha 0.01 Standard Error for Comparison 0.7362
Critical T Value 2.831 Critical Value for Comparison 2.0846
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are 3 groups (A, B, etc.) in which the means are not significantly different from one another.

LSD All-Pairwise Comparisons Test of GERMINATI for PROCESSIN

PROCESSIN	Mean	Homogeneous Groups
HAND S	78.188	A
POD P	73.128	B

Alpha 0.01 Standard Error for Comparison 0.5206
Critical T Value 2.831 Critical Value for Comparison 1.4740
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
All 2 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of GERMINATI for VARIETIES*PROCESSIN*HARVESTIN

VARIETIES	PROCESSIN	HARVESTIN	Mean	Homogeneous Groups
ASHA	HAND S	PHYSIO	83.688	A
ASONTEM	HAND S	PHYSIO	79.938	B
ASHA	POD P	PHYSIO	79.513	B
ASHA	HAND S	FARMER H	78.938	B
ASHA	POD P	FARMER H	74.750	C
ASONTEM	HAND S	FARMER H	70.188	D
ASONTEM	POD P	PHYSIO	70.125	D
ASONTEM	POD P	FARMER H	68.125	D

Alpha 0.01 Standard Error for Comparison 1.0412
Critical T Value 2.831 Critical Value for Comparison 2.9480
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are 4 groups (A, B, etc.) in which the means are not significantly different from one another.

LSD All-Pairwise Comparisons Test of PURITY for VARIETIES

VARIETIES	Mean	Homogeneous Groups
ASHA	92.839	A
ASONTEM	91.524	B

Alpha 0.01 Standard Error for Comparison 0.1916
Critical T Value 2.831 Critical Value for Comparison 0.5424
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
All 2 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of PURITY for HARVESTIN

HARVESTIN	Mean	Homogeneous Groups
PHYSIO	95.114	A
FARMER H	89.249	B

Alpha 0.01 Standard Error for Comparison 0.1916
Critical T Value 2.831 Critical Value for Comparison 0.5424
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
All 2 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of PURITY for VARIETIES*PROCESSIN

VARIETIES	PROCESSIN	Mean	Homogeneous Groups
ASHA	HAND S	93.885	A
ASONTEM	HAND S	92.175	B
ASHA	POD P	91.793	B
ASONTEM	POD P	90.874	C

Alpha 0.01 Standard Error for Comparison 0.2709
Critical T Value 2.831 Critical Value for Comparison 0.7671
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are 3 groups (A, B, etc.) in which the means are not significantly different from one another.

LSD All-Pairwise Comparisons Test of PURITY for VARIETIES*HARVESTIN

VARIETIES	HARVESTIN	Mean	Homogeneous Groups
ASHA	PHYSIO	95.345	A
ASONTEM	PHYSIO	94.884	A
ASHA	FARMER H	90.333	B
ASONTEM	FARMER H	88.165	C

Alpha 0.01 Standard Error for Comparison 0.2709
Critical T Value 2.831 Critical Value for Comparison 0.7671
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are 3 groups (A, B, etc.) in which the means are not significantly different from one another.

LSD All-Pairwise Comparisons Test of PURITY for PROCESSIN*HARVESTIN

PROCESSIN	HARVESTIN	Mean	Homogeneous Groups
HAND S	PHYSIO	95.964	A
POD P	PHYSIO	94.265	B
HAND S	FARMER H	90.096	C
POD P	FARMER H	88.401	D

Alpha 0.01 Standard Error for Comparison 0.2709
Critical T Value 2.831 Critical Value for Comparison 0.7671
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
All 4 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of PURITY for PROCESSIN

PROCESSIN	Mean	Homogeneous Groups
HAND S	93.030	A
POD P	91.333	B

Alpha 0.01 Standard Error for Comparison 0.1916
Critical T Value 2.831 Critical Value for Comparison 0.5424
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
All 2 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of PURITY for VARIETIES*PROCESSIN*HARVESTIN

VARIETIES	PROCESSIN	HARVESTIN	Mean	Homogeneous Groups
ASHA	HAND S	PHYSIO	96.363	A
ASONTEM	HAND S	PHYSIO	95.565	A
ASHA	POD P	PHYSIO	94.327	B
ASONTEM	POD P	PHYSIO	94.203	B
ASHA	HAND S	FARMER H	91.407	C
ASHA	POD P	FARMER H	89.257	D
ASONTEM	HAND S	FARMER H	88.785	D
ASONTEM	POD P	FARMER H	87.545	E

Alpha 0.01 Standard Error for Comparison 0.3831
Critical T Value 2.831 Critical Value for Comparison 1.0848
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are 5 groups (A, B, etc.) in which the means are not significantly different from one another.

LSD All-Pairwise Comparisons Test of VIGOUR for VARIETIES

VARIETIES	Mean	Homogeneous Groups
ASONTEM	37.059	A
ASHA	35.813	A

Alpha 0.01 Standard Error for Comparison 4.9027
Critical T Value 2.831 Critical Value for Comparison 13.881
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are no significant pairwise differences among the means.

LSD All-Pairwise Comparisons Test of VIGOUR for HARVESTIN

HARVESTIN	Mean	Homogeneous Groups
PHYSIO	47.169	A
FARMER H	25.703	B

Alpha 0.01 Standard Error for Comparison 4.9027
Critical T Value 2.831 Critical Value for Comparison 13.881

Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
All 2 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of VIGOUR for VARIETIES*PROCESSIN

VARIETIES	PROCESSIN	Mean	Homogeneous Groups
ASONTEM	POD P	37.094	A
ASHA	HAND S	37.031	A
ASONTEM	HAND S	37.025	A
ASHA	POD P	34.594	A

Alpha 0.01 Standard Error for Comparison 6.9335
Critical T Value 2.831 Critical Value for Comparison 19.631
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are no significant pairwise differences among the means.

LSD All-Pairwise Comparisons Test of VIGOUR for VARIETIES*HARVESTIN

VARIETIES	HARVESTIN	Mean	Homogeneous Groups
ASHA	PHYSIO	48.688	A
ASONTEM	PHYSIO	45.650	AB
ASONTEM	FARMER H	28.469	BC
ASHA	FARMER H	22.938	C

Alpha 0.01 Standard Error for Comparison 6.9335
Critical T Value 2.831 Critical Value for Comparison 19.631
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are 3 groups (A, B, etc.) in which the means are not significantly different from one another.

LSD All-Pairwise Comparisons Test of VIGOUR for PROCESSIN*HARVESTIN

PROCESSIN	HARVESTIN	Mean	Homogeneous Groups
HAND S	PHYSIO	47.994	A
POD P	PHYSIO	46.344	A
HAND S	FARMER H	26.063	B
POD P	FARMER H	25.344	B

Alpha 0.01 Standard Error for Comparison 6.9335
Critical T Value 2.831 Critical Value for Comparison 19.631
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
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 for PROCESSIN

PROCESSIN	Mean	Homogeneous Groups
HAND S	37.028	A
POD P	35.844	A

Alpha 0.01 Standard Error for Comparison 4.9027
Critical T Value 2.831 Critical Value for Comparison 13.881
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are no significant pairwise differences among the means.

LSD All-Pairwise Comparisons Test of VIGOUR for VARIETIES*PROCESSIN*HARVESTIN

VARIETIES	PROCESSIN	HARVESTIN	Mean	Homogeneous Groups
ASHA	HAND S	PHYSIO	53.313	A
ASONTEM	POD P	PHYSIO	48.625	AB
ASHA	POD P	PHYSIO	44.063	ABC
ASONTEM	HAND S	PHYSIO	42.675	ABC
ASONTEM	HAND S	FARMER H	31.375	ABC
ASONTEM	POD P	FARMER H	25.563	ABC
ASHA	POD P	FARMER H	25.125	BC
ASHA	HAND S	FARMER H	20.750	C

Alpha 0.01 Standard Error for Comparison 9.8054
Critical T Value 2.831 Critical Value for Comparison 27.763
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are 3 groups (A, B, etc.) in which the means are not significantly different from one another.

LSD All-Pairwise Comparisons Test of SEEDWEIGH for VARIETIES

VARIETIES	Mean	Homogeneous Groups
ASONTEM	47.261	A
ASHA	46.555	B

Alpha 0.01 Standard Error for Comparison 0.0405
Critical T Value 2.831 Critical Value for Comparison 0.1148
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
All 2 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of SEEDWEIGH for HARVESTIN

HARVESTIN	Mean	Homogeneous Groups
PHYSIO	49.517	A
FARMER H	44.299	B

Alpha 0.01 Standard Error for Comparison 0.0405
Critical T Value 2.831 Critical Value for Comparison 0.1148
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
All 2 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of SEEDWEIGH for VARIETIES*PROCESSIN

VARIETIES	PROCESSIN	Mean	Homogeneous Groups
ASONTEM	POD P	47.263	A
ASONTEM	HAND S	47.259	A
ASHA	POD P	46.560	B
ASHA	HAND S	46.550	B

Alpha 0.01 Standard Error for Comparison 0.0573
Critical T Value 2.831 Critical Value for Comparison 0.1623
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are 2 groups (A and B) in which the means are not significantly different from one another.

LSD All-Pairwise Comparisons Test of SEEDWEIGH for VARIETIES*HARVESTIN

VARIETIES	HARVESTIN	Mean	Homogeneous Groups
ASHA	PHYSIO	49.782	A
ASONTEM	PHYSIO	49.251	B
ASONTEM	FARMER H	45.270	C
ASHA	FARMER H	43.328	D

Alpha 0.01 Standard Error for Comparison 0.0573
Critical T Value 2.831 Critical Value for Comparison 0.1623
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
All 4 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of SEEDWEIGH for PROCESSIN*HARVESTIN

PROCESSIN	HARVESTIN	Mean	Homogeneous Groups
POD P	PHYSIO	49.535	A
HAND S	PHYSIO	49.499	A
HAND S	FARMER H	44.310	B
POD P	FARMER H	44.288	B

Alpha 0.01 Standard Error for Comparison 0.0573
Critical T Value 2.831 Critical Value for Comparison 0.1623
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are 2 groups (A and B) in which the means are not significantly different from one another.

LSD All-Pairwise Comparisons Test of SEEDWEIGH for PROCESSIN

PROCESSIN	Mean	Homogeneous Groups
POD P	46.911	A
HAND S	46.904	A

Alpha 0.01 Standard Error for Comparison 0.0405
Critical T Value 2.831 Critical Value for Comparison 0.1148
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are no significant pairwise differences among the means.

LSD All-Pairwise Comparisons Test of SEEDWEIGH for VARIETIES*PROCESSIN*HARVESTIN

VARIETIES	PROCESSIN	HARVESTIN	Mean	Homogeneous Groups
ASHA	POD P	PHYSIO	49.810	A
ASHA	HAND S	PHYSIO	49.755	A
ASONTEM	POD P	PHYSIO	49.260	B
ASONTEM	HAND S	PHYSIO	49.243	B
ASONTEM	HAND S	FARMER H	45.275	C
ASONTEM	POD P	FARMER H	45.265	C
ASHA	HAND S	FARMER H	43.345	D
ASHA	POD P	FARMER H	43.310	D

Alpha 0.01 Standard Error for Comparison 0.0811
Critical T Value 2.831 Critical Value for Comparison 0.2295
Error term used: REP*VARIETIES*PROCESSIN*HARVESTIN, 21 DF
There are 4 groups (A, B, etc.) in which the means are not significantly different from one another.

APPENDIX 2: ANOVA

Student Edition of Statistix 9.0 08/05/2015, 15:18:09

Analysis of Variance Table for GERMINATION

Source	DF	SS	MS	F	P
REP	3	8.731	2.910		
VARIETIES	1	406.481	406.481	187.47	0.0000
PROCESSIN	1	204.778	204.778	94.44	0.0000
HARVESTIN	1	226.047	226.047	104.25	0.0000
VARIETIES*PROCESSIN	1	6.169	6.169	2.85	0.1065
VARIETIES*HARVESTIN	1	2.503	2.503	1.15	0.2948
PROCESSIN*HARVESTIN	1	29.934	29.934	13.81	0.0013
VARIETIES*PROCESSIN*HARVESTIN	1	30.128	30.128	13.90	0.0012
Error	21	45.533	2.168		
Total	31	960.306			

Grand Mean 75.658 CV 1.95

Analysis of Variance Table for PURITY

Source	DF	SS	MS	F	P
REP	3	0.72773	0.24258		
VARIETIES	1	13.8207	13.8207	47.08	0.0000
PROCESSIN	1	23.0351	23.0351	78.46	0.0000
HARVESTIN	1	275.244	275.244	937.52	0.0000
VARIETIES*PROCESSIN	1	1.25215	1.25215	4.27	0.0515
VARIETIES*HARVESTIN	1	5.82258	5.82258	19.83	0.0002
PROCESSIN*HARVESTIN	1	2.813E-05	2.813E-05	0.00	0.9923
VARIETIES*PROCESSIN*HARVESTIN	1	0.02820	0.02820	0.10	0.7597
Error	21	6.16534	0.29359		
Total	31	326.096			

Grand Mean 92.182 CV 0.59

Analysis of Variance Table for VIGOUR

Source	DF	SS	MS	F	P
REP	3	471.91	157.30		
VARIETIES	1	12.44	12.44	0.06	0.8017
PROCESSIN	1	11.22	11.22	0.06	0.8115
HARVESTIN	1	3686.23	3686.23	19.17	0.0003
VARIETIES*PROCESSIN	1	12.56	12.56	0.07	0.8007
VARIETIES*HARVESTIN	1	146.84	146.84	0.76	0.3921
PROCESSIN*HARVESTIN	1	1.73	1.73	0.01	0.9253
VARIETIES*PROCESSIN*HARVESTIN	1	322.27	322.27	1.68	0.2095
Error	21	4038.17	192.29		
Total	31	8703.37			

Grand Mean 36.436 CV 38.06

Analysis of Variance Table for 1000 SEEDWEIGHT

Source	DF	SS	MS	F	P
REP	3	0.01951	0.00650		
VARIETIES	1	3.98325	3.98325	303.11	0.0000
PROCESSIN	1	3.781E-04	3.781E-04	0.03	0.8669
HARVESTIN	1	217.831	217.831	16576.1	0.0000
VARIETIES*PROCESSIN	1	7.813E-05	7.813E-05	0.01	0.9393
VARIETIES*HARVESTIN	1	12.2389	12.2389	931.33	0.0000
PROCESSIN*HARVESTIN	1	0.00690	0.00690	0.53	0.4766
VARIETIES*PROCESSIN*HARVESTIN	1	0.00195	0.00195	0.15	0.7037
Error	21	0.27597	0.01314		
Total	31	234.358			

Grand Mean 46.908 CV 0.24

APPENDIX 3: ANOVA FUNGAL

Student Edition of Statistix 9.0 01/08/2015, 08:50:31

Analysis of Variance Table for aspergilus flavus

Source	DF	SS	MS	F	P
Rep	3	1.00000	0.33333		
Harvest	1	722.000	722.000	1378.36	0.0000
Process	1	4.116E-31	4.116E-31	0.00	1.0000
Variety	1	18.0000	18.0000	34.36	0.0000
Harvest*Process	1	4.786E-31	4.786E-31	0.00	1.0000
Harvest*Variety	1	2.00000	2.00000	3.82	0.0641
Process*Variety	1	1.662E-30	1.662E-30	0.00	1.0000
Harvest*Process*Variety	1	3.762E-33	3.762E-33	0.00	1.0000
Error	21	11.0000	0.52381		
Total	31	754.000			

Grand Mean 8.7500 CV 8.27

Analysis of Variance Table for fusarium

Source	DF	SS	MS	F	P
Rep	3	16.5000	5.50000		
Harvest	1	578.000	578.000	735.64	0.0000
Process	1	3.385E-36	3.385E-36	0.00	1.0000
Variety	1	12.5000	12.5000	15.91	0.0007
Harvest*Process	1	8.520E-33	8.520E-33	0.00	1.0000
Harvest*Variety	1	8.00000	8.00000	10.18	0.0044
Hrocess*Variety	1	1.145E-30	1.145E-30	0.00	1.0000
Harvest*Process*Variety	1	5.360E-32	5.360E-32	0.00	1.0000
Error	21	16.5000	0.78571		
Total	31	631.500			

Grand Mean 7.8750 CV 11.26

Analysis of Variance Table for microformina

Source	DF	SS	MS	F	P
Rep	3	60.0000	20.0000		
Harvest	1	480.500	480.500	272.72	0.0000
Process	1	4.076E-31	4.076E-31	0.00	1.0000
Pariety	1	2.00000	2.00000	1.14	0.2988
Harvest*Process	1	3.050E-31	3.050E-31	0.00	1.0000
Harvest*Variety	1	0.50000	0.50000	0.28	0.5998
Process*Variety	1	1.848E-31	1.848E-31	0.00	1.0000
Harvest*Process*Variety	1	1.706E-31	1.706E-31	0.00	1.0000
Error	21	37.0000	1.76190		
Total	31	580.000			

Grand Mean 7.0000 CV 18.96

Analysis of Variance Table for aspergilus niger

Source	DF	SS	MS	F	P
Rep	3	7.37500	2.45833		
Harvest	1	666.125	666.125	556.76	0.0000
Process	1	1.505E-36	1.505E-36	0.00	1.0000
Variety	1	6.12500	6.12500	5.12	0.0344
Harvest*Process	1	1.961E-31	1.961E-31	0.00	1.0000
Harvest*Variety	1	3.12500	3.12500	2.61	0.1210
Process*Variety	1	3.732E-30	3.732E-30	0.00	1.0000
Harvest*Process*Variety	1	8.691E-33	8.691E-33	0.00	1.0000
Error	21	25.1250	1.19643		
Total	31	707.875			

Grand Mean 8.4375 CV 12.96